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EVALUATION OF THE RETRIEVAL OF METALLURGICAL DOCUMENT REFERENCES USING THE UNIVERSAL DECIMAL CLASSIFICATION IN A COMPUTER-BASED SYSTEM

by
Robert R. Freeman

April 1, 1968

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AMERICAN INSTITUTE OF PHYSICS
UDC PROJECT
REPORT NO: AIP/UDC-6
National Science Foundation Grant GN-433

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ABSTRACT

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UDC 025.3+025.4UDC+651.83.012.1:681.322.06:669.1

Explanation of UDC Numbers

025.3 - Cataloging and indexing - Information retrieval systems

025.4UDC - Decimal classifications - UDC

651.83 - Indexing and retrieval methods

.012.1- experimental testing and evaluation

681.322.06 - Digital computer programs

669.1 - Ferrous Metallurgy

EVALUATION OF THE RETRIEVAL OF METALLURGICAL DOCUMENT REFERENCES USING THE UNIVERSAL DECIMAL CLASSIFICATION IN A COMPUTER-BASED SYSTEM

by

Robert R. Freeman

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Evaluation of the Retrieval of Metallurgical Document References Using UDC as the Index Language in a Computer-Based System

by

Robert R. Freeman

1. Introduction. Documentation of the literature of the field of ferrous metallurgy is provided by two English-language services. In the United States, the American Society for Metals (ASM), located in Metals Park, Ohio, published an abstracting and indexing service, the Review of Metal Literature (RML), covering all fields of metallurgy until 1967.* Bibliographic and indexing data were also maintained in a computer-based system and an experimental information searching service operated for several years. The development of this service, including two indexing languages - the WRU Semantic Code and later an alphabetically-arranged natural-language thesaurus - is documented in many published articles. Coverage of the ASM service exceeded 20,000 articles per year.

The Iron and Steel Institute (ISI) located in London, England, publishes a section entitled Abstracts of Current Literature and Book Notices - Iron and Steel Institute. Annual author and alphabetic subject indexes are provided.

ISI also publishes the same abstracts on 3x5 cards, distributing batches fortnightly. These cards, unlike the published abstracts, include Universal Decimal Classification (UDC) numbers as a guide to the subject content. The Abstract and Book Title Card Service, or ABTICS, system has accounted for over 65,000 abstracts since it began in 1960. The current rate is somewhat over 9,000 abstracts per year.

Owing to the greater scope (all metallurgy vs. ferrous metallurgy alone) ASM's system includes a great many of ISI's 9,000 items each year within its coverage. The overlap is not known precisely, but it is estimated to be anywhere from 5-30% of ASM's total coverage.

---

* In January, 1968, Metals Abstracts, combining and superseding RML and Metallurgical Abstracts, commenced publication as a joint service of ASM and The Institute of Metals (London).

The use of UDC in the field of metallurgy is enhanced by the existence of the Special Subject Edition for Metallurgy[1], prepared by the C669-Metallurgy Committee of the International Federation for Documentation (FID) in 1964. Mr. J.P. Saville of ISI, who, with Mr. E. Öhman of FID, first suggested use of UDC for a metallurgical documentation service[2], served as rapporteur of the committee.

When the American Institute of Physics (AIP) commenced its UDC Project in 1965, Mr. Morris L. Pearl of ISI suggested that the ISI ABTICS cards would provide a useful corpus of document references for a test of the UDC in a mechanized retrieval system. ASM subsequently agreed to cooperate in any suitable way. The AIP, ASM, and ISI staffs reached the agreement in 1966 that the 1965 coverage of both services would provide a useful basis for a test of UDC,according to methods described below.

2. Objectives. A previous report of the AIP/UDC Project documented the demonstration of the fact that UDC may be used as the indexing language in a mechanized system[3]. The objective of the work reported here and in a separate report to be published subsequently is to illustrate and analyze the results which may be obtained in a test environment which reasonably simulates some of the features of a real information retrieval system.

---

1. Universal Decimal Classification: Special Subject Edition for Metallurgy, FID No. 362, ISI Special Report 84, The Iron and Steel Institute, London, September 1964.

2. E. Öhman and J. P. Saville, "The Universal Decimal Classification Applied to Metallurgical Literature", Journal of the Iron and Steel Institute, 177, 183-188 (May, 1954).

3. Robert R. Freeman and Pauline Atherton, File Organization and Search Strategy Using the Universal Decimal Classification in Mechanized Reference Retrieval Systems, Report No. AIP/UDC-5, American Institute of Physics, New York, September 15, 1967. National Science Foundation Grant GN-433.

The purposes behind this objective are as follows:

(a.) to be able to show which, if any, features of the UDC influence the performance of the retrieval system, in either direction;

(b.) to be able to show which, if any, indexing policies used by ISI in conjunction with UDC are particularly appropriate or inappropriate, especially with respect to the transition from a manual to a mechanized system.

(c.) to be able to show which, if any, search strategies are particularly appropriate or inappropriate for use in the system.

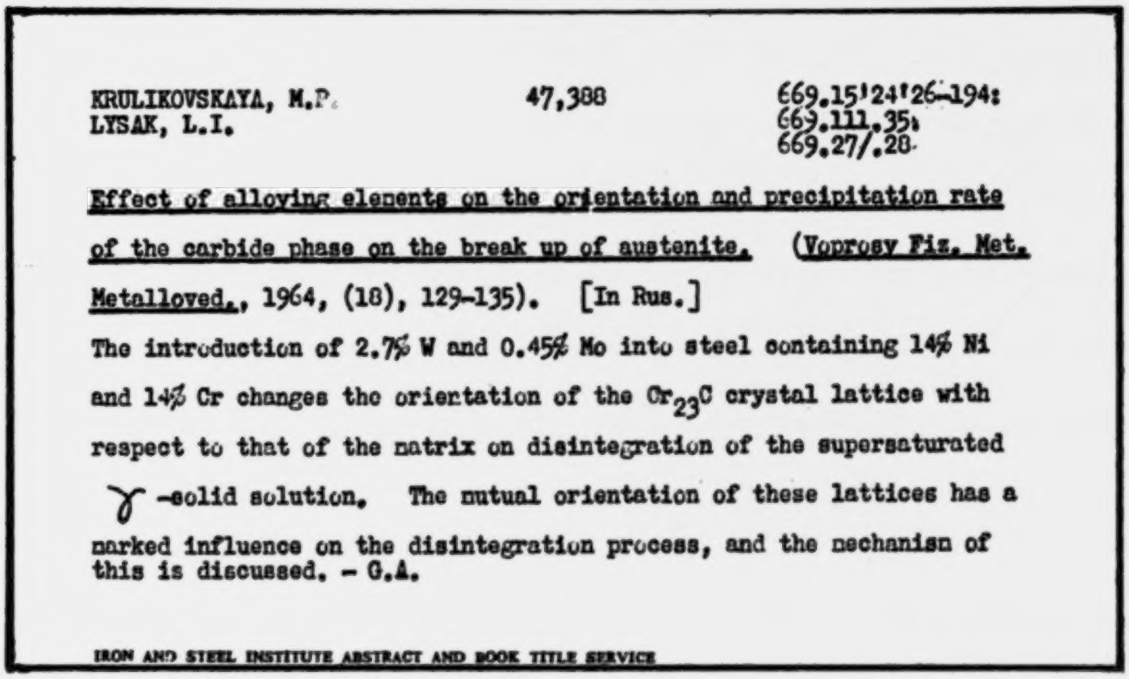
Knowing in advance that a significant number of documents have been indexed by two different indexing languages, one may be tempted to evaluate the relative performance of the two. However, it is our opinion that the confounding of the many factors involved in an information retrieval system makes such a goal unrealistic for this limited study, if, indeed, it is possible at all. Instead, the procedure of parallel searches, described below, has been used only for the purpose of discovery of relevant document references not retrievable by the UDC-based system. This result, in turn, enables an analysis of search failures to be conducted.

3. Methods and Experimental Design. In this section we have attempted to describe the factors which are likely to influence the results of the study. Throughout the experiment, there are implicit assumptions that the conditions described represent a statistically valid sample drawn from the actual ISI system and that static sample files adequately simulate the dynamic real conditions. In this study, we have neither sought to check the veracity of these assumptions, nor have we noted any evidence which leads us to question them.

3.1. Characteristics of the document collection. As indicated above, the ISI ABTICS service had produced a cumulative file of over 65,000 abstracts by the end of 1967. The abstracts represent coverage of periodical literature and books. The test collection consisted of 9,159 abstracts to periodical articles. The abstracts were all published during 1965 by ISI. The form of the abstracts is illustrated by Figure 1. The file of abstracts is organized by twenty-three fortnightly batches* and by author name within batches, with anonymous papers filed under anon.

FIGURE 1

SAMPLE OF ISI ABTICS CARD



KRULIKOVSKAYA, M.P.
LYSAK, L.I.

47,388

669.15'24'26-194:
669.111.35:
669.27/.28

Effect of alloying elements on the orientation and precipitation rate of the carbide phase on the break up of austenite. (Voprosy Fiz. Met. Metalloved., 1964, (18), 129-135). [In Rus.]

The introduction of 2.7% W and 0.45% Mo into steel containing 14% Ni and 14% Cr changes the orientation of the $Cr_{23}C$ crystal lattice with respect to that of the matrix on disintegration of the supersaturated γ-solid solution. The mutual orientation of these lattices has a marked influence on the disintegration process, and the mechanism of this is discussed. - G.A.

IRON AND STEEL INSTITUTE ABSTRACT AND BOOK TITLE SERVICE

3.2. Characteristics of indexing records. Each abstract card included a set of one or more UDC numbers, presented, according to standard UDC practice, as a chain of numbers related by the colon and plus sign syntactic symbols. Sets of unrelated concepts** are allotted separate lines. Only a single order of UDC numbers is given with each card, the user of a manual system being expected to permate the individual numbers and file according to his own interests.

---

* the twenty-fourth batch, consisting entirely of book titles, was excluded from the sample.

** i.e. where a document is concerned with A and B, separately, not in relation to each other.

Two significant differences exist between the manual ABTICS indexing records and the equivalent in the experimental retrieval system. First, each UDC number in a chain is treated as a separate, individually retrievable descriptor, no consideration being given to the syntactic devices. Second, the UDC "point-zero", "point-double-zero", and "dash" auxiliary forms, which appear in normal form to be part of the UDC number to which they are suffixed, are also treated as separate descriptors within the machine system.

The quantitative data given in Figures 2 and 3 reflect the indexing records as they appear in the machine system. The reader should recall, however, that the 2,921 UDC descriptors used are not equivalent to 2,921 mutually exclusive classes, but are, instead extensively and explicitly related classes. Figure 4 shows the same data in graphic form. In light of the evidence given by Houston and Wall[4] for a variety of other indexes, we should not be surprised to see that the use of UDC descriptors closely follows the log-normal distribution.

---

[4] N. Houston and E. Wall, "The Distribution of Term Usage in Manipulative Indexes", American Documentation, 15(2), 105-114 (April, 1964).

FIGURE 2

Quantitative Characteristics of UDC Indexing Records

Number of Postings: 28,131

Number of Documents Indexed: 9,159

Number of UDC Descriptors Used: 2,921

$$\text{Average Depth of Indexing} = \frac{28{,}131}{9{,}159} = 3.07$$

Range: 1-8

$$\text{Average Loading of Descriptors} = \frac{28{,}131}{2{,}921} = 9.63$$

Range: 1-2073

FIGURE 3

Distribution of Use of UDC Descriptors

Column W = Number of Documents Posted to a Descriptor

Column X = Number of UDC Descriptors Having the Number of Postins Shown in Column W

Column Y = Number of Descriptors Having W or fewer Documents Posted (Cumulation of X)

Column Z = Number of Documents Posted to Descriptors Having W or fewer Documents Posted (Cumulation of W times X)

W	X	Y	Z
1	1234	1234	1234
2	421	1655	2076
3	233	1888	2775
4	177	2065	3483
5	100	2165	3983
6	81	2246	4469
7	51	2297	4826
8	65	2362	5346
9	44	2406	5742
10	43	2449	6172
11	27	2476	6469
12	32	2508	6853
13	21	2529	7126
14	32	2561	7574
15	16	2577	7814
16	19	2596	8118
17	21	2617	8475
18	14	2631	8727
19	14	2645	8993
20	11	2656	9213
21	18	2674	9591
22	8	2682	9767
23	10	2692	9997
24	10	2702	10237
25	9	2711	10462
26	9	2720	10696
27	9	2729	10939
28	11	2740	11247
29	12	2752	11595
30	5	2757	11745
31	8	2765	11993
32	5	2770	12153
33	4	2774	12285
34	8	2782	12557
35	8	2790	12837
36	4	2794	12981
37	5	2799	13166
38	2	2801	13242
39	3	2804	13359
40	7	2811	13639
41	1	2812	13680
42	4	2816	13848
43	7	2823	14149
44	1	2824	14193
45	5	2829	14418
46	4	2833	14602
47	1	2834	14649
48	3	2837	14793
49	1	2838	14842
50	2	2840	14942
51	1	2841	14993
52	3	2844	15149
53	1	2845	15202
54	2	2847	15310
56	3	2850	15478
57	1	2851	15535
59	1	2852	15594
61	1	2853	15655
62	1	2854	15717
63	2	2856	15843
66	1	2857	15909
67	1	2858	15976
72	2	2860	16120
73	1	2861	16193
74	2	2863	16341
75	1	2864	16416
76	2	2866	16568
78	1	2867	16646
80	3	2870	16886
81	1	2871	16967
84	1	2872	17051
86	1	2873	17137
87	1	2874	17224
90	2	2876	17404
93	1	2877	17497
95	1	2878	17592
96	1	2879	17688
98	1	2880	17786
100	1	2881	17886
101	1	2882	17987
108	2	2884	18203
109	1	2885	18312
113	2	2887	18538
116	2	2889	18770
118	1	2890	18888
121	1	2891	19009
129	1	2892	19138
130	1	2893	19268
131	2	2895	19530
133	2	2897	19796
139	2	2899	20074
147	1	2900	20221
151	1	2901	20372
155	1	2902	20527
160	1	2903	20687
167	1	2904	20854
169	1	2905	21023
176	1	2906	21199
184	1	2907	21383
218	1	2908	21601
221	1	2909	21822
231	1	2910	22053
237	1	2911	22290
264	1	2912	22554
273	1	2913	22827
286	1	2914	23113
391	1	2915	23504
393	1	2916	23897
411	1	2917	24308
445	1	2918	24753
600	1	2919	25353
705	1	2920	26058
2073	1	2921	28131

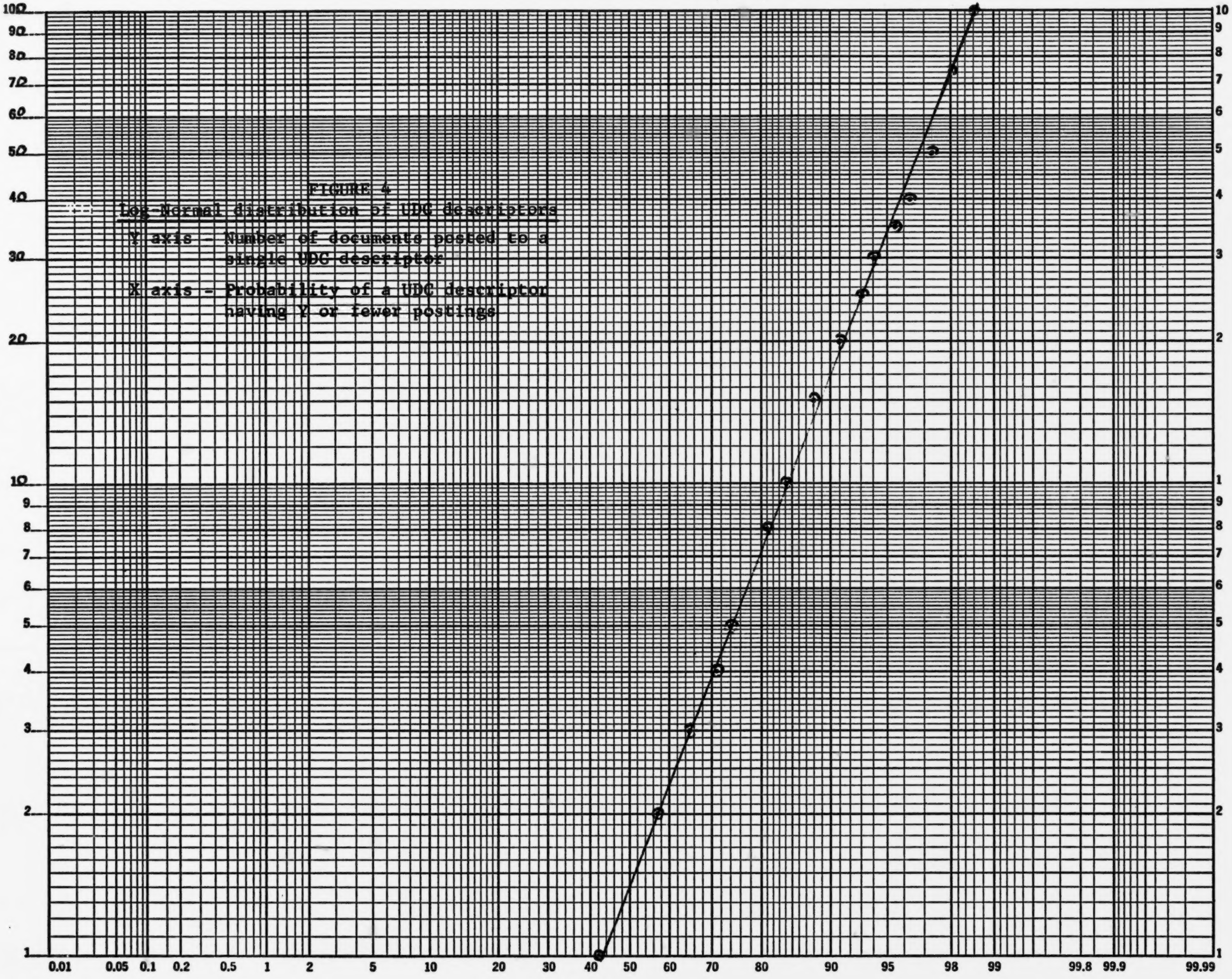


FIGURE 4

Log-Normal distribution of UDC descriptors

Y axis - Number of documents posted to a single UDC descriptor

X axis - Probability of a UDC descriptor having Y or fewer postings

3.3. Characteristics of the Retrieval System and Records. The Combined File Search System (CFSS),a package of programs developed distributed by IBM Corporation for the 1401 computer, was used for the experimental system. Actual operation took place on an IBM 360/30 with a 16K memory and four tape drives, using the 1401 emulation mode. Thorough program documentation is available from IBM Corporation[5], while the use of the system in conjunction with UDC is described elsewhere by the author[6]. It should be noted that the Combined File Search System was also employed by the American Society for Metals.

It was necessary to decide upon how much of the manual ABTICS record to convert to machine-readable form. The minimum requirement would have been the UDC indexing and the ABTICS abstract number for each record, the maximum including in addition the complete bibliographic reference and the abstract. The advantage of the minimum requirement would be lower cost both in data conversion to machine-readable form and in less computer time used, chiefly in tape handling operations. The disadvantage would be that manual retrieval and reproduction of the ABTICS cards would be required in order to provide a basis for relevance judgements. Since the CFSS has a rather poor report generator from the point of view of ready intelligibility to the untrained user, we decided that use of the ABTICS cards for relevance judgement purposes was desirable.

---

[5] D.D. Prentice, G. deGraw, A. Smith, and I.A. Warheit, 1401 Information Storage and Retrieval System (The Combined File Search System), IBM 1401 General Program Library Number 1401-10.3.047 (Version 2), San Jose, California, IBM Corporation, April 21, 1965.

[6] Freeman and Atherton, *op. cit.*

Consequently, a minimum machine-readable record seemed to be indicated. Since the manual ABTICS file was ordered by author within fortnightly batch, it was necessary to devise a record identification code which included these items as well as the abstract number. As a check against possible record identification code errors, we also keypunched the document titles.

3.4. Characteristics of the Query Set. We felt that the best approach to simulating a real UDC-based information retrieval system would be found in the use of real questions, submitted by metallurgists who had no knowledge of or concern with the internal characteristics of the system. As explained above, we also desired to pose the same queries to the system operated by the American Society for Metals as a check on the performance of the UDC-based system.

3.4.1. Source. The American Society for Metals therefore agreed to provide twenty-five questions which had been processed against its 1965 files and which, in ASM's judgement, were representative of questions submitted to a real metallurgical information service. The number of questions selected was purely arbitrary.

3.4.2. Negotiation. ASM supplied the project with a record of the question; notes added by an analyst who usually negotiated by telephone or letter with the source of the question; the encoded form of the question, as processed by the ASM system; and a list of Review of Metal Literature (RML) abstract numbers produced as a result of the search. No record of either the analyst's judgement of the system output or the source's judgement of the material transmitted to him was obtained.

The records described in the preceding paragraph were transmitted to ISI in order that appropriate UDC numbers might be assigned for the experimental retrieval system. Since the source of the questions could not be revealed by ASM, no further negotiation would have been possible, even if it had been desirable.

Mr. J.P. Saville of ISI suggested UDC numbers for each question and provided a set of notes outlining how the numbers should be combined into logical statements. Mr. Saville directs the assignment of UDC numbers to ABTICS cards and, as described above, was a prime mover in the development of the Special Subject Edition of UDC for Metallurgy.

3.4.3. Translation to Logical Statement. Using the formulations thus obtained, the author translated the questions into logical statements in the form and format required by the CFSS. An apparent drawback of CFSS was that, although all statements could be expressed successfully, the lack of sufficient capabilities for "nesting" made some statements unnecessarily lengthy and time-consuming to set up. For example if a question calls for

$$\{[A \text{ or } (B \text{ and } C)] \text{ and } (D \text{ or } E)\},$$

it is necessary to keypunch the equivalent of

$$[(A \text{ and } D) \text{ or } (A \text{ and } E) \text{ or } (B \text{ and } C \text{ and } D) \text{ or } (B \text{ and } C \text{ and } E)]$$

for CFSS. However, our experience with the experimental data indicate, as one might guess from observing that the depth of indexing is close to 3, that extremely complex logical statements are generally unnecessary and even harmful. Thus the net effect of the drawback is diminished.

3.4.4. Search Strategy Variations. Part of our aim was to experiment with search strategies in conjunction with the UDC. For this reason, each question was encoded and run at least two and often three or even four different ways. Search statements generally involved use of one or a combination of the strategies listed below. It was impossible to follow a consistent pattern of strategy variation, owing to the nature of the questions and the relationship of the UDC to them.

3.4.4.1. Synonym Control. By its nature and purpose, the UDC number generally represents the confounding of synonyms and near-synonyms which would have to be accounted for by the searcher in a system with an uncontrolled vocabulary.

However, it still remains that UDC, not being truly a faceted classification and being organized by scientific discipline and by industry, creates numbers which must be treated as synonyms with respect to a given question, where natural language provides a single term. Thus "brittleness" is represented by 539.56, where it is thought of as a physical property of materials, while it is also 620.192.49 where it is thought of as a structural defect in the testing of materials. Likewise, the chemical elements appear twice, according to whether the viewpoint is that of chemistry or of engineering and metallurgy, or even four times, if one includes their occurence in minerals and the mining of the minerals.

A carefully controlled information service will generally avoid the potential difficulties of such problems, particularly if the indexers are also involved in search analysis. However, as we shall show later, control of internal UDC-synonyms and partial synonyms is an important search strategy.

3.4.4.2. More Specific, Hierarchically-related Concepts. The first version of the search statement for each question involved requests for exact matches between UDC numbers in the indexing record and those in the statement. However, it is to be expected that a user who wants to know about open-hearth furnaces (669.183.21) should have a chance to see a paper on open-hearth furnace walls (669.183,211.3). CFSS provides for this by permitting the analyst to suffix a \$ sign to signal that he wants either an exact match only or all more specific, hierarchically-related concepts as well.

3.4.4.3. Broader, Hierarchically-related Concepts. If the search analyst specifies the use of UDC number X_{11}, which is subsumed under a broader concept X_1, then a possible search variation is to request (X_1 or $X_{11}\$$), which demands retrieval on an exact match with X_{11}, or with any more specific topics, or with the related, but broader topic.

3.4.4.4. Filial Concepts. Continuing the preceding example, if X_1 subsumes not only X_{11}, but also X_{12}, X_{13}, X_{14}, X_{15}, there are two additional strategies which have the effect of retrieving documents on potentially related topics. The request (X_1 or $X_{11}\$$ or X_{12} or X_{13} or X_{14} or X_{15}) would retrieve all covered by 3.4.4.3. and documents indexed by filial concepts as well. The request ($X_1\$$) is even broader, being designed to retrieve even documents indexed by concepts hierarchically-related, but more specific than the filial concepts.

3.4.4.5. Diminished Logical Restrictions. If the analyst specified (X and Y) as the search requirement, two search strategy variations involve loosening the restriction of the logical product. One variation calls instead for (X or Y), the other simply for (X).

All of these variations as well as others have been suggested by Cleverdon and Mills[7]. Those described here were the set which were empirically useful in this experiment. Detailed descriptions of each question, the ASM and ISI analysts' notes, UDC numbers, and the various search formulations will be found in the Appendix.

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[7] C.W.Cleverdon and J. Mills, "The Analysis of Index Language Devices", pp. 451-454 in H.P. Luhn (Ed.), Automation and Scientific Communication, American Documentation Institute, Washington, 1963.

3.4.5. Summary of the Query Set. In summary, there were 25 original questions, submitted by metallurgists or others interested in metallurgical topics, who had no knowledge of the system or that a test was being conducted. The search strategy variations produced a total of 64 queries submitted to the machine system. These queries included 590 UDC descriptors, of which 510 were "truncated", i.e. demanded retrieval on either an exact match or on a more specific, hierarchically-related term. The UDC descriptors were grouped in 196 logical units, each unit consisting of either a single UDC class number or an expression of the logical product of several such classes.

From these figures we can also observe that, on the average, we required the logical product of three classes (590/196) in order to satisfy the conditions specified. Recalling that the depth of indexing is also almost exactly three, we may predict that there will be considerable variation in the number of documents retrieved by various search strategies for a given question. However, the reader is warned that the distribution of UDC descriptors is not even over all of the questions.

3.5. Relevance Judgements.

3.5.1. Assembly of the Search Results. The ISI ABTICS abstract numbers retrieved by each search strategy were merged into a single list of numbers for each search question, a record being kept of which strategies caused retrieval of each document. The corresponding abstract cards were pulled from the file and xeroxed as "batch-one" for each question.

The next task was to establish which of the documents were retrieved by the ASM system were covered by the ISI ABTICS service in 1965, regardless of whether they had been retrieved by the UDC search. Those which were retrieved by both searches were, of course, readily identified by comparison of the abstracts published by the two services. The remainder, i.e. those covered by ISI ABTICS, but not retrieved by UDC, were identified by comparing the ASM abstracts, published in Review of Metal Literature with the name (i.e. author) index published by ISI[8], and subsequently with the ISI ABTICS abstract. The ABTICS card abstracts of this latter group (retrieved only by ASM) were then assembled and xeroxed as "batch two" for each question.

The relevance judges were not advised of the meaning of the two batches of abstracts delivered for each search. Neither were they given any indication of which strategies retrieved which abstracts, nor even what the final search strategies were.

3.5.2. The Judging Environment. Probably the most exhaustive list of conditions affecting relevance judgements has been given by Cuadra and Katter and their associates[9]. We shall attempt to characterize the judging environment by recourse to this model, to the extent that we have data available. The model indicates that a relevance judgement is a product of the interaction of characteristics of the document, the information requirement statement, the judge, and the judgement conditions. The judgement is then translated into a relevance rating value by application of the available mode of expression. Many of the individual characteristics, discussed in detail above, are only noted again here for the sake of completeness.

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[8] Index to Publications of the Iron and Steel Institute, 1965, pp. 1-111, London, 1966.

[9] System Development Corporation, Experimental Studies of Relevance Judgements: Final Report. Volume 1. Project Summary, Santa Monica, California, 30 June 1967. Report TM-3520/001/00. NSF Contract C-424.

3.5.2.1. The Document.

a. Subject matter. Ferrous metallurgy and closely related areas.

b. Diversity of content within the document. In most cases, the document upon which the relevance judgement was based was an abstract. The judges were free to consult the full document upon which the abstract was based if they chose. Considering both possibilities, the diversity of content probably includes a range of quantitative property, process,and physical composition data, scientific theory, experimental design, and narrative, descriptive, and critical text. Reported data may have been generated from laboratory experiments, controlled pilot plant scale operators, or full industrial plant scale operations. Although the subject content is probably very homogeneous, the factors listed above potentially could have had considerable effect upon relevance judgements.

c. Difficulty level. While no data are available, we shall assume that this factor was not important.

d. Scientific "hardness" of the document. If we adhere strictly to Cuadra and Katter's definition[10] of "hardness", the abstracts used for judgement are almost certainly less "hard" than the documents on which they were based. Aside from this point, we may note the diversity of content among the documents, which ranged from scientific papers, cast in the traditional form of physical or chemical research reports; engineering papers on plant design, materials testing, or macro-scale operations, for example;

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[10] Ibid., p. 34. "The hardness of a particular document is indicated by the precision of the language and the relationship among the stated aims of the document, the conclusions, the methodology of inquiry, and the supporting data. If any of these, or the relationship between them, is ill-defined, nonexistent, unclear, questionable, or otherwise precarious, the document would be considered less 'hard'."

trade magazine articles on industrial news, market studies, etc.; and reviews of various types. There was some evidence that the judges applied different standards to abstracts of reviews than to "harder" documents.

e. Amount of "information" in the document. Assuming that this item refers to the occurrence of unexpected subject matter, we have no data to report.

f. Level of condensation and textual attributes. The abstracts ranged from simple title abstracts (bibliographic references with no accompanying text) to a length of several hundred words. The most typical set probably ranged from 50-100 words per abstract. We have no data on the type-token ratio.

g. Special qualitative attributes. No data.

3.5.2.2. The Information Requirement Statement.

a. Subject matter. The subject matter was "on target", i.e. one could probably not conceive of an information service which was better qualified to receive the questions, considering the subject of its collection.

b. Diversity of content within a question. All questions appeared to be "single" questions, as opposed to several separate questions embedded in one.

c. Difficulty level, Specificity, and Functional Ambiguity. The range of difficulty was evidenced by the fact that the UDC search analyst encoded many requests essentially without comment, while in some cases he added notes such as

(1) "this .... is both very general and very specific,"

(2) "This is remarkably vague, and the definition does not clarify it";

(3) "This is a severe test for any scheme of classification or any thesaurus.....".

In a few cases, the "definition" (notes added by the ASM search analyst during negotiation with the source) considerably augmented or modified the original statement. The specificity of the questions is indicated by the fact that in almost all cases, less than one half of one percent of the file was retrieved. See the discussion of "recall" below.

d. Textual Attributes. No specific data.

3.5.2.3. The Judges. Cuadra and Katter list the following characteristics of judges in their model: knowledge/experience, intelligence, cognitive style, biases, judging experience, vigilance level, judgement attitude, concept of relevance, use orientation, expectations regarding distributions, and error preference. The kind of controlled experimentation required to relate each of these items in detail to the present work was beyond the scope of the study. Instead, we shall present a condensed description of the judges, referring the reader also to the following section on judgement conditions.

Since we did not have recourse to the actual sources of the questions, we decided to request that representatives of ISI and ASM act as relevance judges. Consequently, what we have are judgements which lie somewhere between those of a system operator and an impartial expert subject specialist. The judges were expert in metallurgical documentation services, but they were at least one step removed from the precise mechanics of this set of searches.

Mr. Saville acted as the ISI judge. It will be recalled that he also served as the search analyst and supervised the indexing of the documents by UDC. Although UDC numbers appeared on the ABTICS cards sent to Mr. Saville for judging, we requested that he disregard them in making his judgements.

Five ASM information analysts took part in the judging, each acting as judge for several of the questions. No question was judged twice. Thus, while all were trained in ASM procedures, we cannot deny the possibility of this set of judgements being confounded by the differing individual environmental and personality characteristics of the judges.

The ISI judge did not communicate with the ASM judges. Therefore, overlooking individual differences among the ASM judgements, we have essentially two independent sets of judgements for each of the twenty-five questions.

The judges were given identical sets of instructions. The instructions, described below, were designed to influence the factors of judgement attitude, concept of relevance, use orientation, and error preference.

3.5.2.4. Judgement Conditions.

a. Amount of time permitted. The judges were instructed to take as much time as they felt was necessary.

b. Order of presentation. The composition of the two batches of abstracts presented for each question has been described. The abstracts were ordered by author in "batch one" and by the order of occurrence of the equivalent abstract in the ASM Review of Metal Literature in "batch two". There was no strategy other than clerical ease of assembly behind the use of these orders.

One incident, however, illustrates the effects of this factor. One abstract of a document which had been retrieved by both systems was accidentally included in both batches submitted to the judges for the question. In one batch, where the abstract appeared with only a few others, it was judged relevant by both judges. In the other batch, where it appeared in the midst of a very large group, almost all of which were judged irrelevant, one of the judges called the same document irrelevant.

c. Size of the document set. See Figure 5 .

d. Breadth of subject matter in the document set. The subject matter was probably quite homogeneous from the point of view of an experienced metallurgical documentalist. It included ferrous metallurgy, chemistry, physics, chemical engineering, mining, mechanical engineering, and materials testing.

e. Use of control judgements. No attempt was made to use control judgements to orient or influence the judges.

f. Social pressure toward convergence. Judgements were made by judges operating alone. The ASM staff who made up one composite judge may have communicated, but since they were each responsible for a different set of questions, the possibility of pressure toward convergence was minimal.

g. Specification of the task. The judges were asked to assume their normal role as operators of a documentation service for metallurgists. They also were asked to assume that

(1) they were not acquainted with the specific professional or work interests of the question-asker other than those reflected in the question itself and the notes attending the negotiation of the search.

(2) the question-asker is an experienced research scientist or engineer.

(3) the question-asker wishes to review for himself all of the pertinent literature prior to commencing work in an area which is related to his professional competence, but new to him in many specific details.

FIGURE 5

Size of the Document Set Presented for Relevance Judgement

	Number of Abstracts		
Question	Batch 1*	Batch 2**	Total
1	8	5	13
2	18	8	26
3	18	4	22
4	23	2	25
5	0	6	6
6	3	4	7
7	16	4	20
8	8	4	12
9	2	22	24
10	0	11	11
11	2	3	5
12	2	3	5
13	0	6	6
14	0	21	21
15	42	19	61
16	0	10	10
17	1	17	18
18	218	15	233
19	40	0	40
20	2	9	11
21	16	5	21
22	62	8	70
23	25	15	40
24	183	4	187
25	18	4	22
TOTAL	707	209	916

Range: 5-233
Mean: 36.6
Median: 20-21

*Batch 1: Retrieved from the ISI ABTICS file by the UDC-based retrieval system

**Batch 2: Covered by both ASM and ISI, but retrieved only by ASM

Abstracts with bibliographic reference data were used for relevance judgements. UDC numbers appeared with the abstracts, but judges were requested not to allow knowledge of UDC to affect their judgement. Judges were requested to refer to the original documents in any cases in which the abstract was too brief or otherwise inadequate to make a judgement.

h. Definition of relevance. No definition was provided, other than that which a judge might infer from the specification of the task.

3.5.2.5. Available Mode of Expression.

a. Type of scale, Number of Rating Categories, and Kind of Response Required. The judges were asked to rate the retrieved documents as (1) relevant, (2) marginally relevant, or (3) non-relevant to the question, given the task specification. They were provided with a space in which to add comments explaining their thoughts or actions.

b. Availability of anchors. No anchoring stimuli were provided.

c. Ease of use. The response form was probably close to the simplest possible form.

3.6. Definition and Method of Derivation of Performance Measures. The confounding of many variables discussed in the preceding section serve to detract from the value of any quantitative performance measures which might be derived. Nevertheless, if one is cautious in attributing overall performance to particular factors, even inadequate measures are better than none.

Three measures have been computed for each question: precision, recall, and specificity. The definitions of the former two are well known, while the last is simply the ratio of the estimated number of relevant documents in the file to the number of documents in the file. This ratio provides a measure of the degree to which the questions put to the system are of a homogeneous type.

The reader is now specifically warned of the difference between the measures of performance reported here and those variously reported elsewhere. The first difference is that which results from the relationship of the judges to the system. As explained above, the judges were not the sources of the questions and they were not precisely either system operators (for this system) or dispassionate subject matter experts. However, the output of the relevance judgement process, a set of supposed relevant documents, corresponds most closely to what is commonly forwarded to the source or user of a real information service. Therefore we shall think of relevance henceforth as system-operator-relevance.

The second difference results from the fact that the given number of relevant documents in the file is an inferred estimate, as described below. Consequently, the performance measures labelled recall and specificity are also estimates.

The reader may recall the theory which states that there is no valid manner of categorizing documents as relevant or non-relevant with respect to a given question; that instead, each document in the file has an objective and algorithmically computable relevance to the question. Without denying the possible philosophical truth of this theory, we found it practical to accept the more rigid three-way categorization of the human judges' decisions. This tactic serves to further differentiate the measures of performance of this study from those reported by some other authors.

Estimating the number of relevant documents in the file for a given question is generally the most difficult part of deriving performance figures. Our original intent was that a reasonably reliable estimate could be obtained directly from the results of the parallel searches of the ISI and ASM files.

Consider Figure 6. The critical figure is the sum of E_R and F_R, i.e. the set of relevant documents not retrieved by either the UDC-based system or by the ASM system, but covered by the ISI ABTICS service. If we can safely assume that this set is small enough to be considered negligible, then recall is easily computed as

$$\frac{A_R + B_R + C_R}{A_R + D_R + C_R + D_R} = \frac{R_R}{N_R + R_R} .$$

Whether or not this assumption is a safe one depends on the extent to which the two systems retrieve the same set of relevant documents from among the set covered by both services. That is, we looked for A_R to be large relative to either B_R or D_R. Unfortunately, for the present set of questions, this condition did not hold true. With respect to the set of documents covered by both services, the two systems acted to a surprising extent as complements of each other.

As a result, it became reasonable to suspect that E_R and possibly F_R were not negligible as originally supposed. Our most reliable estimate of recall under these circumstances turned out to be the ratio $A_R/(A_R + D_R)$. The best estimate of the total number of relevant documents in the ISI ABTICS file is therefore

$$\frac{A_R + B_R + C_R}{A_R/(A_R + D_R)} = \frac{R_R}{A_R/(A_R + D_R)}$$

A statistical explanation of this estimate is offered in Appendix B. The probabalistic nature of the recall and specificity figures should now be clear to the reader.

FIGURE 6

Relationship of Documents Retrieved by ASM and UDC Systems

		Retrieved by ASM	Not Retrieved by ASM		TOTAL
			Covered	Not Covered	
Retrieved by ISI/UDC		A_R A_N	B_R B_N	C_R C_N	R_R R_N
Not Retrieved by ISI/UDC	Covered	D_R D_N	E_R ▨	F_R ▨	N_R ▨
	Not Covered	G_R G_N	▨	▨	▨
TOTAL		H_R H_N	▨	▨	▨

Subscripts: R = relevant
N = non-relevant

4. Experimental Data. This section includes a complete summary of each question and the data generated in relation to it, while the following section concentrates on synthesis of the results and generalization of some of the characteristics of the system of interest to our objectives.

The data are presented in the following format, where X represents the question numbers, 1-25:

4.X.1. Question

4.X.1.1. Statement in natural language, as received by ASM.

4.X.1.2. Notes added by the ASM search analyst during negotiation with the user.

4.X.1.3. Notes added by the ISI search analyst during UDC encoding.

4.X.2. UDC descriptors chosen, including their frequency of use in the document file.

4.X.3. Encoded logical statements of question. As described above, usually two or more statements were formulated for each question and run separately.

4.X.4. Results and Analysis.

4.X.4.1. Relevance judgements made by ASM and ISI judges on the composite output of all searches run for a given question. Judge 1 was the ASM judge and Judge 2, the ISI judge.

4.X.4.2. Derived performance characteristics, including estimated recall, estimated number of relevant documents in the ISI ABTICS file, precision, and estimated specificity. All of these measures are defined and discussed in section 3.6.

4.X.5. Failure analysis. In many cases, the judges disagreed in making relevance judgements. Therefore, a "failure" is defined as a judgement by at least one judge that

4.X.5.1. (1) a document retrieved by ASM and covered by ISI, but not retrieved by UDC, is relevant to the question (the definition does not include marginally relevant); or

4.X.5.2. (2) a document retrieved by UDC is non-relevant to the question, i.e. was judged to be in the non-relevant category of the three categories available.

Note: For the convenience of readers who may wish to skip the detailed experimental data, section 5 follows immediately. Section 4 is continued following page 64.

Section 4 continues following page 64

5. Analysis and Summary.

5.1. System Operating Characteristics. Before proceeding to consider the data on system performance reported here, the reader should review the definitions of these measures as applied to this report. Specific data for each question are given in section 4 and a tabular summary of the data used for computation of the performance measures is given in Appendix II.

5.1.1. Expected number of references retrieved. Twenty-five questions produced a total of 707 document references retrieved. The range was 0-218, the mean, 28.3 (standard deviation, 53.2) and the median, 8. With so few observations and the knowledge that the system is an experimental one, it does not seem worthwhile to attempt to arrive at a predictive probability distribution for the system.

We can conclude that the system probably would not produce so many references on the average as to be a burden on search analysts whose job it would be to filter the output for the user who posed the question. However, if the file were ten times as large, a not uncommon size for many real systems, it could become necessary to devise more refined and sophisticated techniques.

5.1.2. Precision. At least one document reference was retrieved in 20 of 25 questions. The overall ratio of relevant documents retrieved to total retrieved is shown in Figure 7.

5.1.3. Estimated recall. The method used for estimating recall required that at least one document reference be retrieved in common by both the UDC system and the ASM system. On this basis, data were obtained for 12 of the 25 questions. The overall estimated recall ratios are shown in Figure 8.

5.1.4. Estimated number of relevant documents. Have made an estimate of recall, based on the retrieval of a common set of documents by both systems, we then divided this figure into the number of relevant documents retrieved by the UDC system to obtain an estimate of the total relevant documents in the file. Whereas many information system tests have relied upon direct observation of the number of relevant documents, the present technique might be termed the "indirect method". For the same 12 questions, the overall average estimated number of relevant documents in shown in Figure 9 .

5.1.5. Estimated Specificity. This measure, the estimated number of relevant documents divided by the file size, 9159, provides a way of predicting the percentage of the file which will be relevant to questions posed to the system. On the basis of the limited data, summarized in Figure 10 , we can predict that, 99% of the time, no more than 1.15% of the file will be relevant to a given question, with an additional 2.4% marginally relevant.

5.1.6. Validity and Utility of the Measures. The complexity of the Cuadra-Katter model alone is enough to make one question the idea of assigning performance measures. Yet it is our belief that system managers are better off with measures that are not precisely accurate, but instead indicate ranges and magnitudes, than with none at all. As predictors of system performance, the measures given above probably suffer from too small a base. They are more valuable as an exercise in methodology of evaluation. We encourage other investigators to repeat or extend the experiments.

Limited though they are, the data are the first, to our knowledge, to result from an application of UDC in a mechanized retrieval system. As such, the measures of performance should lend encouragement to those who are interested in similar applications. There is little room for doubting whether reasonable levels of performance can be attained.

Before passing on to a summary of some of the factors affecting performance, we shall make one further note of the relevance judgement situation. The values for estimated recall (and consequently those for estimated relevant documents and estimated specificity) of relevant documents led us to suspect that there was a significant difference in the judgement criteria applied by the two judges. Several tests were applied in an attempt to support or reject this inference:

(a.) A variance ratio test using Snedecor's F showed that the variances between samples (i.e., between judges) were sufficiently alike to warrant the assumption that they were estimates of the same population variance.

(b.) Application of the "Student's t" test led to the conclusion that the difference between the mean values of the two judges' results was significant, i.e. that a difference of the magnitude observed (0.295 vs. 0.668) would be likely to occur only about once in a hundred observations.

(c.) An analysis of variance showed that the variance attributable to the judges was not necessarily significant, the chance of observing such values being somewhat greater than 5%.

We were thus led to no definite conclusion. Possibly an analysis of variance which takes into account the interaction of the judges with particular questions or groups of questions, such as those of high specificity vs. those of low specificity, would help to explain the differences observed. We also note that, when the relevant and marginal categories are combined, there is no difference of any significance between the two samples. This may indicate that, in the absence of explicit instructions for differentiating "relevant" from "marginally relevant", the judges applied slightly differing criteria.

Whatever the case may be, the data from this first test can be of only limited value. We are more interested in discovering why the system performed as it did than precisely how well it performed.

FIGURE 7

Average Precision Ratios as a System Operating Characteristic

		Relevance Categories	
		Relevant only	Combined Relevant + Marginal
Judge 1	Precision	0.615	0.780
	Std. error	±0.015	±0.011
Judge 2	Precision	0.723	0.899
	Std. error	±0.015	±0.011
Combined	Precision	0.668	0.842
	Std. error	±0.007	±0.006

FIGURE 8

Average Estimated Recall Ratios as a System Operating Characteristic

		Relevance Categories	
		Relevant only	Combined Relevant + Marginal
Judge 1	Est. Recall	0.295	0.373
	Std. error	±0.018	±0.008
Judge 2	Est. Recall	0.668	0.299
	Std. error	±0.018	±0.008
Combined	Est. Recall	0.480	0.336
	Std. error	±0.011	±0.004

FIGURE 9

Average Estimated Number of Relevant Documents per Question as a System Operating Characteristic

		Relevance Categories	
		Relevant only	Combined Relevant + Marginal
Judge 1	Estimated Relevant Documents/Question	58.29	122.77
	Std. error	±26.99	±52.11
Judge 2	Estimated Relevant Documents/Question	44.08	147.47
	Std. error	±26.99	±54.43
Combined	Estimated Relevant Documents/Question	51.18	134.58
	Std. error	±19.39	±37.28
Estimated Upper and Lower Limits at 99% Confidence Level*		±54.29	±100.38

* Using Student's t distribution for small samples

FIGURE 10

Average Estimated Specificity Ratios as System Operating Characteristics

		Relevance Categories	
		Relevant only	Combined Relevant + Marginal
Judge 1	Specificity	.0063	.0134
Judge 2	Specificity	.0048	.0161
Combined	Specificity	.0056	.0147
Estimated Upper and Lower Limits at 99% Confidence Level*		±.0059	±.0110

*Using Student's t distribution for small samples

5.2. Summary of Failures. Although it is useful to have some notion of how well a system is performing, the goal of evaluation must lead to an analysis of why it performs that way. One might well conceive of "success analysis" as a tactic for evaluation. Presumably there would be suitable content-analytic or semantic-closeness measures which would reflect the degree to which the system accomodated itself to the user's intention, or,less desirable, *vice-versa*. However, this type of analysis, if not beyond the scope of behavioral science methodology, has at least not yet been clearly integrated with the evaluation of information system performance.

Consequently, we shall confine our analysis to the negative aspect, *viz*., why didn't the system do what we intended perfectly. While this type of analysis is more readily made, the number of instances chalked up to questionable judgements serves to remind us of the subtleties of the judging process, even where the judges are more-or-less impartial experts.

Although the technique of failure analysis is not new, we attempted to let the reasons for failure establish themselves, rather than to work from a predetermined list. Thus, while there may well be other possible sources of error in information systems those reported here may all be observed by the reader.

However, there are two important points to be kept in mind while reviewing the failures summarized here. First, a given failure frequently has a mixture of interrelated causes. It often appears reasonable to say that, if the structure of the indexing language had been slightly altered, the indexer or search analyst would have acted differently. The components of a real information system are not the independent and rational units of an abstract model. The reader should henceforth remember that a statement that a failure resulted from causes a, b, and c is a matter of probability, not certainty.

The other point deals with assessment of blame for failures. The terms "error" and "failure" should be regarded as convenient shorthand throughout this discussion. The reader should recall that all of the experience, training, and policies which affected the indexing and search analysis processes resulted from a manual information system which was created and operated without any notion of a mechanized system. Indeed, this statement applies to the UDC itself. To say that a failure resulted from an indexing error overlooks the likely fact that the indexing was correctly done according to the policies established for a manual system with a given intended use.

Having stated these warnings, we may now proceed to outline the classes of failures. The causes of failure were grouped into five broad classes, which include (a.) the indexing process, (b.) the search analysis process, (c.) the machine system process, (d.) the UDC, and (e.) the judgement process. The first three contain a further element of subdivision, that of whether the process involved intellectual decisions or was programmed or clerical in nature. Since the project under which the present work was performed is basically interested in the UDC, we shall consider it first.

5.2.1. UDC Structure or Class Definition. Little, if anything at all, can be added here to the sizeable body of knowledge and criticism built up over many years with respect to the design of information languages and the UDC in particular. This being among the first reports of use of UDC in a mechanized retrieval system, it can serve to demonstrate that the effects of known types of problems are magnified by the formality of a mechanized system. The rapid, adaptive, heuristic characteristics of manual search provide a "forgiveness" factor which is not present when one is required to commit himself to a given strategy and accept the results. The fact that some characteristic of the UDC was at least partially the cause of some failures in 40% of the questions in this experiment points to the need for attention to this point.

5.2.1.1. First-level problems. On the surface, many observed failures can be laid to the existence of partial synonyms, vaguely defined classes, ambiguity, lack of specificity, and "convenience classes". By lack of specificity is meant the existence of a class which is actually no more than the logical sum of several distinct concepts which have not been allotted separate UDC numbers. Thus a document on "a" is indexed by UDC number "(a +b +c)", there being no separate "a", "b", and "c" available, and is retrieved erroneously in response to a search for concept "c". In the case of "convenience classes", "(a + b + c)" exists as a class which subsumes "a", "b", and "c", but the sum has no nominal or functional identification distinct from the three subclasses taken together.

Both of these latter types of problems, lack of specificity and "convenience classes" are undoubtedly reflections of the fact that UDC has been developed with manual systems in mind. If a document deals with several distinct, but closely related topics, fewer cards need be made and filed if a single unifying class is defined. Provided that there are relatively few documents which deal with only one of the several topics subsumed by a class, the irrelevant material is quickly filtered out by a manual search. In the computer-based system, however, the file will be large and a search for more specific hierarchically-related classes is easy to accomplish. In sum, while the indexing policy for a manual system may be "use the general class which subsumes closely related topics", the policy for a mechanized system would be "use the most specific classes". These contrasting policies would be reflected in the development of the UDC for various uses. At the very least, the highly specific classes should be available for use where needed, even if they are not needed in all systems.

5.2.1.2. Second-level problems. However, it is not only the existence of specific classes (and associated policies) which affects the performance of UDC in mechanized retrieval systems, but the theory according to which the classes are defined and the rules governing the statement of relationship of classes which are the subjects of a given document. This more basic level accounts for the first-level problems of partial synonymy, vagueness, and ambiguity. We shall borrow the terms used by Gardin to describe these two aspects of an information language, paradigmatic and syntagmatic relationships respectively.

5.2.1.2.1. Paradigmatic relationships. The vocabulary of metallurgy and related areas of engineering, science, and technology have been widely discussed in terms of facet analysis, role indicators, semantic codes, and general categories. An approximate listing of the general categories revealed by the file used in the present experiment and by the Special Subject Edition of UDC for Metallurgy might be

a. Material (element, mineral, manufactured product, etc.)

b. Process

  (1) natural

  (2) man-operated

c. Machine, apparatus, device

d. Purpose, intended use

e. Attribute

 (1) physical state

 (2) formally-defined (measurable) property

 (3) form, shape

 (4) position, location

The UDC, as pointed out in an earlier report[11], provides a limited facet structure, consisting of time, place, ethnic group, form of document, language of document, and general subject categories. As a concession to the need for further facets, a general point-of-view auxiliary and two special auxiliaries are provided, the latter two being developed separately within major disciplines and technologies as needed.

In the UDC, metallurgy and related areas, particularly materials testing and mechanical engineering, are reasonably good examples of the attempt to use the limited tools available for expression of general categories. However, owing to the lack of sufficient facet indicators, the lack of relational operators, discussed below, and perhaps also to the desire for simple UDC notation, there remain many examples of hierarchies derived by mixing of concepts from different general categories or facets.

For example, if we have machine "a", material "b", and attribute "c", we might form a UDC class "abc" which represents the use of "a" to produce "b" which has attribute "c". Now if we have a request for everything on material "b", there are at least two classes which must be searched, "b" and "abc". The present experiment revealed several cases in which even an expert in the use of UDC in metallurgy did not recall all of the possible alternatives under which relevant material was indexed. The problem is familiar to classificationists as "distributive relatives".

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[11] Freeman and Atherton, _op_. _cit_.

5.2.1.2.2. Syntagmatic Relationships. The capability to specify the relationship of two or more concepts which are the subjects of a given document is virtually non-existent in the UDC. The existence of a relationship is stated by the use of the colon symbol, but no indication is conveyed as to the nature of the relationship.

The consequence of this lack is the need to form classes of the type discussed above, which are logical products of classes taken from two or more facets or general categories, i.e., to make a pre-coordinated classification. Thus, a set of relational operators of the degree of completeness suggested by Perreault[12] would not only allow more definite specification of syntagmatic relationships among existing classes with respect to a given document. It would also provide for simplification of the UDC by reduction of the number of classes. However, as we move away from a large number of highly pre-coordinated classes toward a smaller number of less complex classes, a greater number of classes would be needed to express the contents of a document.

Therein lies a troublesome point for the classification which is intended for use in both manual and mechanized systems. In manual systems, brief notations are considered desirable. Even in its present semi-faceted condition, UDC is sometimes criticized because of the number of characters used in classifying an average document. In a computer-based system, while the length of the notation is of less concern, within reasonable limits, the search analyst's job becomes much easier if the classes are not highly pre-coördinated.

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[12] J. Perreault, "Categories and Relators: A New Schema", Revue Internationale de la Documentation, 32, 136-144 (1965) and Emendations to the Relator Schema (January, 1968?), available from the author, School of Library and Information Services, University of Maryland, College Park, Maryland.

We can conclude, then, that the testing of a system which employs a set of relational operators such as Perreault's seems to be in order as a next step in exploring use of UDC in mechanized retrieval systems. However, we can somewhat pessimistically predict that the full benefit cannot be derived therefrom without further revision and systematization of the UDC structure.

5.2.2. System failures attributable to the indexing process.

5.2.2.1. Failure to index a concept which appears in the document abstract.

This source of failure was the most frequently occurring failure, affecting some of the results in 17 out of 25 questions. However, we must again recall that the indexing was done according to policies devised for a manual card index system. The situation is quite analogous to some major mechanized systems, in which a limited set of the most important indexing terms is chosen for use in a published index, while a more comprehensive set is stored for use in the mechanized retrieval system. In the present case, the ISI indexing, done for a manual system, could be augmented readily (at a greater cost, of course) for a computer-based system.

It must be admitted that the criterion for assessing an indexing failure, existence of a concept in an abstract which is not represented in the indexing record, is not infallible. However, the abstract and the indexing record are not independent, but represent two degrees of compression and selection of the information contained in the original document. In fact, many information systems combine the two by constructing an abstract in more-or-less telegraphic style from a set of indexing terms.

In a few cases it was possible to infer that the problems of UDC structure and notation, discussed above, may have been a direct cause of indexing failures. The -1/-9 auxiliaries, for example serve to indicate (1) state and form of metals (-1/-4), (2) details of machines and apparatus (-5/-8), and (3) process characteristics, variables, and control conditions (-9). The .0 auxiliaries mix properties, processes, and equipment. Now, if a document deals with corrosion-resistant (.018.8), creep-resistant (.018.44) steel (669.14) strip (-418) and wire (-426) a number such as 669.14-418-426.018.44.018.8 might be called for. However, the complexity and possible ambiguity of such a notation may work to intimidate an indexer into selecting a less specific number or not indexing one or more concepts.

Assuming the formulation of new indexing policies consistent with the requirement of deeper indexing for a mechanized retrieval system, indexer performance might be enhanced by a special worksheet, which would encourage explicit recognition of the facets of each topic in a document. A sample design of such a worksheet is given in the following section.

5.2.2.2. Failure to be as specific as possible. Once again, this type of failure is probably indicative of the policy adopted for use in a manual system.

5.2.2.3. Wrong concept indexed. This minor source of failure seems to reflect genuine errors. The cause may lie in the transfer of natural language terminology to UDC codes. One tactic for overcoming such errors might be to have indexers write controlled natural language terms and have the computer system translate the terms into equivalent UDC numbers. The meaning of the present highly pre-coordinated UDC classes often requires so many words to express that this procedure could be too tedious and error-prone to be worthwhile.

5.2 2.4. Transcription of indexing record. This source of error is common to most information systems. The present computer system provides a program for automatically checking all input against a table of legitimate codes, but this program was not used. Transpositions and elisions, probably the most common clerical errors, are easy to detect in a natural language descriptor system. In a digital code system, such as UDC, such errors might result in illegitimate codes which would be caught by a dictionary look-up procedure, but other errors might well result in legitimate, but wrong codes which would not be caught. The fact that four errors of this type were discovered in only approximately 200 documents analyzed (ca. 600 UDC numbers out of over 28,000 in the file) for errors leads one to the conclusion that the clerical error rate should be investigated more thoroughly.

5.2 3. System failures attributable to the question analysis and search formulation process.

5.2 3.1. Failure to specify a UDC number which expresses a concept in the question. More than any other cause of failure, this is an indicator of the complexity of the UDC structure. The search analyst, as stated above, was probably better qualified by experience to suggest UDC numbers to represent the search concepts than any other person. Yet in eight out of 25 questions, there were additional UDC numbers which could have been used to retrieve relevant documents.

5.2.3 2. UDC numbers too specific. In this rather minor cause of failure, it appeared that the indexing accurately reflected the document content, but the search analyst suggested that a more specific, hierarchically related UDC number be used for the search. To some extent, ambiguities in the definition of UDC classes may have been the cause.

5.2 3.3. UDC numbers too general. Only one case of this type of failure was observed, possibly being attributable to ambiguities in class definition.

5.2.3.4. Non-optimum search logic. The use of logical product, sum, or difference requirements as part of the statement of conditions for satisfying a search request is common to most present-day information systems. As shown by Rolling[13], certain operating characteristics of an information system can be observed over a period of time to yield reasonably accurate tools for predicting the number of documents that will be retrieved by any probable search formulation. As indicated in section 3 of this paper, the searches were formulated and run without even knowledge of the frequency of use of the various UDC numbers in the indexing records. Consequently, it was not possible to predict the effects of the tactics used.

5.2.3.4.1. Logical statement too tight. In four cases, the system failed to retrieve relevant documents because the search statement required more concepts to be present to satisfy the question than were actually necessary.

5.2.3.4.2. Logical statement too loose. Eleven searches were affected to some extent by the tactics of removing some of the restrictions on the statement suggested by the search analyst. It should be recalled that the results of several searches for each question were merged into a single set of abstracts presented to the judges. Knowledge of the system operating characteristics would have helped to prevent some of these difficulties.

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[13] Loll N. Rolling, "A Computer-Aided Information Service for Nuclear Science and Technology", Journal of Documentation, 22(2), 93-115 (June,1966).

5.2.3.5. Transcription of search record. Errors of this type are predictable and appear to have been minimized.

5.2.4. Machine system design problems.

5.2.4.1. Inadequate processing of UDC Notation. This type of failure was anticipated. The UDC provides a notational device for synthesizing special class numbers, thereby avoiding an even greater excess of pre-coordinated classes. If A.1 and A.2 are two classes subsumed by A, then by the notation A.1'2 we can represent a third class which is semantically related to the former two, but has distinct properties of its own which are not inherent in the former two. Thus, 669.15 represents alloy steels in general, 669.24 represents nickel, and 669.26 represents chromium. By notational synthesis, 669.15'24'26 represents nickel-chromium alloy steels.

The difficulty is easily seen. Assume that we have a request for documents about chromium alloy steels, 669.15'26. The present system, in which left-to-right matching takes place between request terms and index terms, does not retrieve a document indexed by 669.15'24'26.

It would be realtively straightforward to program a step during the computer-editing of the input UDC numbers which would perform either of the following transformations:

a. 669.15'24'26 ⟶ 669.15'24+669.15'26

b. 669.15'24'26 ⟶ 669.15+669.24+669.26

However, both of these transformations introduce ambiguities which may result in retrieval errors. What is needed is the ability to request 669.15x'26, where x represents any string of characters, including a null string. Although this capability could be programmed, we did not wish to alter the existing programs of the Combined File Search System for this experiment.

5.2.4.2. False coordination of UDC auxiliaries with main class numbers. The UDC special auxiliaries, represented by .01.../.09... and -1/-9 were treated as independent descriptors in the experimental system, even though they are frequently dependent upon the main class number to which they are appended for their meaning. Consequently, it was possible for a document indexed by X.052:Y to be retrieved by a request for X:Y.052, the result being retrieval of a document which is wildly irrelevant to the question. Our data indicate that such false coordinations are probably a trivial problem, but further work using larger files or files with different indexing characteristics could conceivably produce a different conclusion.

5.2.4.3. Error during file creation. There are many possible causes for the computer system rejecting input. An operational information system would anticipate the problem and provide for entry of corrections.

5.2.4.4. Unexplained machine search failures. Some difficulty was encountered, apparently with requests which involve only a single term or a logical sum expression. In some cases, some of the appropriate documents were retrieved and others rejected.

5.2.5. Unsupported interpretations or inferences by judges. Questionable judgements. Many examples of judgements which could only be explained by inferences made by the judges on the basis of their interpretations of the questions and their expert knowledge of metallurgy were in evidence. The situation was particularly true in the case of documents retrieved only by the ASM system, but covered by the ISI ABTICS service. In 10 of the 25 questions at least one judge decided that some members of this set of documents were relevant, although neither the indexing record or the exact words of the document abstract confirmed the judgement directly.

The frequency of occurrence of this situation has serious implications for those who design or set indexing policy for information systems. However, one can predict that such questionable judgements will always occur to some extent, especially where intermediaries are interposed between system and user.

The possibility that what Cuadra and Katter have called "social pressure toward convergence" may have been a factor should not be dismissed. If a judge is presented with a set of documents which he knows has been retrieved by at least one of two systems, perhaps there is some subtle pressure to agree that the documents are relevant.

FIGURE 11

SUMMARY OF SYSTEM FAILURES

[Data should not be interpreted without reference to the accompanying discussion]

Source of Failure (one failure may have several sources)	Questions in Which this Source Was a Cause of Failure (Approximate number of affected items given in parentheses, otherwise 1 is implied)
1. UDC structure or class definition	1(3), 6(2), 7(9), 8, 9, 14(3), 20(7), 22, 24(4), 25(5)
2. Indexing process	
a. Failure to index a concept which appears in the document abstract	1(2), 2(2), 6(2), 8(3), 9(16), 10(2), 11, 12, 13, 14(5), 16(4), 20, 21(2), 22(2), 23(3), 24(5), 25(2)
b. Failure to be as specific as possible	14(5), 15(2)
c. Wrong concept indexed	2(2), 17
d. Transcription of indexing record	3, 14, 15, 23
3. Search formulation process	
a. Failure to specify a UDC number which expresses a concept in the question	1, 8, 9, 14(6), 16, 18(4), 20(8), 22
b. Too specific	1, 2(2), 17
c. Too general	7(3)
d. Logical statement too tight	7, 8, 9, 10
e. Logical statement too loose	3(2), 4(19), 7(5), 8(8), 15(21), 18(165), 19(37), 21(3), 22(32), 23(6), 25
f. Transcription of search record	15
4. Machine system design problems	
a. UDC notation not adequately handled by present system	9(3), 25(2)
b. False coordination of UDC auxiliaries with main class numbers	7(2), 24(1)
c. Document record apparently rejected from file during file creation	4
d. Unexplained machine search failures	15(28), 16(20), 18(151), 22(2), 23
5. Unsupported interpretations or inferences by judges. Questionable judgements.	
a. Judgements of relevance	1, 5(4), 8(2), 9(5), 13, 15(3), 16(4), 17(7), 18(4), 23
b. Judgements of non-relevance	1, 2(2), 7(3), 15(13), 24(2)

6. Conclusions and Recommendations. On the basis of a limited experiment in a test environment which reasonably simulates a real information system, we feel justified in encouraging those who wish to make use of UDC as the indexing language in a computer-based retrieval system. To the extent that the observed results are reliable, valid, and indicative, the operating characteristics of the experimental system are surprisingly good, especially when one recalls that the indexing was done with a purely manual system in mind.

The results, particularly the failure analyses, revealed some points which should be seriously considered by system designers and managers who intend to use UDC as the indexing language in their system. These points may be grouped as (1) search strategies and predictive tools, (2) hierarchical searching, (3) new indexing policies, and (4) revisions and innovations in the UDC.

6.1. Search strategies and predictive tools. It is doubtful whether many manual information retrieval systems have kept precise data on the frequency of use of the set of terms available for indexing. Consequently, searching a manual system involves only selection of all relevant terms and formulation of a statement of the question using the terms and appropriate logical operators.

However, such frequency data are readily available from a computer-based system. For the present experiment, we have shown that the frequency of use of individual UDC numbers follows the log-normal distribution which was suggested as a common characteristic of information systems by Houston and Wall[14]. That is, a very high percentage of the UDC numbers are used to index only a few documents each.

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[14] Houston and Wall, op. cit.

Now, it is well known that the use of the logical product ("and") and difference ("but not") operators has the effect of increasing the precision level of a system at the possible risk of a decreased level of recall of relevant documents. But, possibly a system operator is willing to adopt a policy that he will not be concerned with the precision level (as he sees it, distinct from what is passed on to the user) provided that the number of documents retrieved can be predicted to be small, e.g. ≤ 20. Frequency-of-use data for the UDC numbers will often show that, if we accept such a policy, many searches can be run without the use of logical product or difference restrictions. We may expect maximum recall of relevant documents and, even if the precision level is low, the total number of documents to be examined gives no cause for concern.

In many cases, it will be necessary to use logical product or difference restrictions in a search. Although this precludes direct calculation of the expected number of documents to be retrieved, the system operator can collect sufficient data from actual searches to be able to predict the number to be retrieved in a probabilistic fashion. Rolling has demonstrated this technique in connection with the Euratom system.[15]

To summarize the point, search strategy in a computer-based retrieval system using UDC needs to take into consideration actual distributions and combinatorial probabilities of the UDC numbers used for indexing. Use of such feedback from the system should be a considerable aid to the system operator in attempting to optimize the balance of levels of recall and precision according to his chosen policy.

6.2. Hierarchical searching. In the present experiment, there were many examples of documents which were chosen as relevant which had been indexed by a term UDC number which represents a concept hierarchically related, but more specific than that specified by the search formulation. Such documents were retrieved by treating the UDC requested number as a "root". There were no failures attributable to this technique. It is highly recommended that all searches be run in this manner. In terms of the system described in this paper, all UDC numbers should appear with a dollar sign ($) suffixed to them.

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[15] L. Rolling, *op. cit.*

It has sometimes been suggested that a retrieval system which uses a hierarchical code such as UDC should be programmed to automatically search at one level higher in the hierarchy if no documents are found at the term requested. The reader should note that this strategy is contradicted by our recommendation that feedback from the system be used in formulating searches. According to the policy recommended here, no search would request a UDC class number to be present which had not been used as to index at least one document, even though the class may exist in theory in the UDC schedule. Thus, if a UDC class number is found not to have been used in the system, it is up to the search analyst to specify whether or not the number for a more general concept should be used.

6.3. New indexing policies. We have suggested, without prejudice to the Iron and Steel Institute, whose use of the UDC was based on policies devised for a manual information retrieval system, that certain new policies should be considered in order to effect improved performance of a mechanized system.

The analysis of failures indicated three areas in which indexing policy could be modified to the probable benefit of system performance in a computer-based system. They are (1) specificity of indexing, (2) depth of indexing, and (3) consistency of indexing.

6.3.1. Specificity of indexing. When several closely related topics are subjects of a document, traditional policy, based originally on single entry catalog practices prescribed use of a general class which describes the subjects collectively. For example, although specific properties of metals were often mentioned in ABTICS abstracts, they were often indexed simply by 539.4/.5, physical properties. When UDC is employed in a computer-based system, we recommend that each specific topic be indexed separately.

6.3.2. Depth of indexing. Once again owing to the need to limit the number of entries made in a manual card file, traditional policy has been to index only the several most important subjects. In the present case, the average was observed to be about three UDC class numbers per document.

In the computer-based system, with more compact storage and fast access to multiple index points, there is no need to exercise such stringent control. While there is no "magic number" for depth of indexing, the evidence of this limited test indicates that more UDC class numbers could be assigned to the average document to advantage. A useful rule of thumb might be to make index entries for each distinctly identifiable topic which appears in the title and abstract of the document.

6.3.3. Consistency of indexing. In section 5.2.1.2.1, a possible range of facets or aspects of metallurgy and its related subjects was outlined. We now suggest that improved performance might result from use of an indexing work sheet which reminds the indexer to consider each of the possible facets which may be anticipated. A sample work sheet is shown in Figure ___. Of course, each information system which uses UDC would need to devise its own form on the basis of subject matter and expected user requirements.

FIGURE 12

A Suggested UDC Indexing Work Sheet for Metallurgy

1. Abstract Number ______________________.
2. Place (Country) ____.
3. Time (generally for production statistics) ___________________.

	Unit or Link 1	Unit or Link 2	Unit or Link 3
4. Material (element, mineral, compound, manufactured product, etc.)			
5. Process (initiated by man)			
6. Phenomenon (natural process)			
7. Machine, apparatus, device			
8. Complex systems (e.g. manufacturing plants, industries)			
9. Purpose, intended use			
10. Physical or chemical state			
11. Measurable property of material			
12. Measurable property of a process			
13. Form, shape of material			
14. Position, location			

6.4 Revisions and Innovations in the UDC. We have presented a detailed discussion of the difficulties which arise at the time UDC-indexed files are searched which are attributable to the structure and class definition system of the UDC (see section 5.2.1.). The problems of revisions and innovations reflect a deep-rooted question for the International Federation for Documentation: can the UDC be universal in the sense of being applicable to all types of information systems? Are the requirements of organizations which will use the UDC for the purpose of systematic single-entry document file organization (e.g. conventional libraries) compatible with those of organizations which will offer services based on deep indexing, highly specific questions, and the use of the computer as an aid?

From the point of view of the latter type of system, continued revision of UDC according to principles and techniques of faceted classifications seems to be indicated. We also recommend the testing of more sophisticated devices for coding syntagmatic relationships, such as the schema of relators suggested by Perreault.[16]

6.5. General Conclusion. The experiment reported here should lend support and encouragement to those who will consider use of UDC in computer-based retrieval systems. No insoluble problems were found, but the long-existent matter of the theory according to which the UDC will be developed in the future is seen to be accentuated by the requirements and capabilities of computer-based systems. Although the data were limited to results from twenty-five search requests run against a file of less than 10,000 document

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16. It is noted with satisfaction that a project which includes this aim commenced activity in December, 1967, under the direction of Mr. Thomas Caless at the George Washington University in Washington, D.C.

references, the performance characteristics derived for the system were entirely satisfactory. It is to be hoped that further tests on a considerably larger scale will be conducted in the near future in order to bridge the gap between the laboratory and the real information system.

6.6. Acknowledgements. We gratefully acknowledge the cooperation and contributions of Messrs. J.P. Saville and Morris Pearl of the Iron and Steel Institute, Mrs. Marjorie Hyslop and her associates of the American Society for Metals, Mrs. Pauline Atherton of Syracuse University, who was principal investigator and later consultant to the project, and Mr. Donald King of Westat Research, Inc., who provided extensive assistance in the development of the methodology for deriving performance measures.

Appendix I

Discussion of Methodology

Observations (or estimates) from each search were made for the following document retrieval profile:

	Document Category		
	Relevant	Not Relevant	Total
Retrieved	Y_{11}	Y_{21}	$Y_{1.}$
Not Retrieved	Y_{21}	Y_{22}	$Y_{2.}$
Total	$Y_{.1}$	$Y_{.2}$	$Y_{..}$

Relevancy of retrieved documents was judged by two persons (J_1, J_2) at two levels, relevant and marginally relevant. Documents judged relevant at these two levels are designated by a single and double prime (e.g. Y'_{11} and Y''_{11}).

Two independent searches were performed using the same questions the first search was made by the system under study and the second search was made by another system. Documents retrieved by each system were sent to the judges for their assessment of relevance. The judges had no knowledge concerning which system produced which documents. Results of the search and corresponding judgements of relevance are given in Table 1 for documents judged relevant and for documents judged to be either relevant or marginally relevant respectively.

Total retrieval ($Y_{1.}$) is estimated from observed system retrieval only from the system under study. Relevant retrieved (Y_{11}) is estimated from judgements made from the subset ($Y_{1.}$) found by the system under study. The recall ratio is based only on relevant documents found by the other system. Thus, it is assumed that relevant documents found by the other system is a representative sample of all relevant documents in the file. The portion of those documents also retrieved by the system under study is the numerator of the recall ratio and the number of relevant documents chosen by the other system is the denominator. The fact that each system retrieved significant numbers of documents covered by, but not retrieved by the other system led us to the conclusion that this technique produces a more accurate estimate of the recall ratio than would be obtained by using the ratio of relevant retrieved by the system (Y_{11}) divided by the total relevant found by both systems. Total relevant documents ($Y_{.1}$) is estimated by dividing (Y_{11}) by the recall ratio.

Since the data for estimated recall, estimated relevant documents, and precision were available as ratios (proportions), they were analyzed by applying an arcsin of the square root of the proportion transformed on each data point, calculating the averages and their standard errors, and then re-transforming these results into percentage terms. Averages in Tables 2, 3, and 4 (Appendix II) were computed by summing the appropriate arcsin transformation values of the questions, dividing by the total number of questions, and re-transforming the results. The averages for total retrieval were calculated directly without a transformation.

The calculation of the standard errors around each of the averages is more cumbersome. To compute these standard errors, the variance from the sample must be estimated. The standard error around each particular variable is found by dividing the variance by the number of observations for a specific variable (e.g. Judge 1), and taking the square root of that number. The most direct method of obtaining the variances is to calculate the total and regression (explained) sum of squares. The difference between them gives the residual (= error = unexplained) sum of squares, which when divided by the corresponding number of degrees of freedom yields the variance (mean square). The square root of this variance is the standard deviation. The data resulting from the above computations is presented in analysis of variance tables for each of the samples.

Formulas used in computations

Let n = total number of observations

n_1 = number of observations for Judge 1

n_2 = number of observations for Judge 2

γ = total number of degrees of freedom

γ_E = explained degrees of freedom; γ_R = residual degree of freedom

X_{ij} = observation, $i = 1, 2$; $j = 1, \ldots, n$

A. Observations and Degrees of Freedom

$n = n_1 + n_2$

$\gamma = n - 1$

γ_E = (No. of Blocks) -1

where No. of Blocks = 2 = Judge 1, Judge 2 = i

$\gamma_R = \gamma - \gamma_E$

B. Sums of Squares

Total

$$\text{TSS} = \sum_{j=1}^{n} X_{ij}^{2} - \frac{\left(\sum_{j=1}^{n} X_{ij}\right)^{2}}{n} \quad , \ i = 1,2 = \text{Judges}$$

$j = 1, \ldots n$ = no. of questions

Explained

$$ESS = \frac{\left(\sum_{j=1}^{n_1} X_{1j}\right)^2}{n_1} + \frac{\left(\sum_{j=1}^{n_2} X_{2j}\right)^2}{n_2} - \frac{\left(\sum_{j=1}^{n} X_{ij}\right)^2}{n}$$

Residual

$$RSS = TSS - ESS$$

C. Variance

σ_T^2 = variance (total)

σ_R^2 = variance (unexplained)

For Average (per Judge)

$$\sigma_R^2 = \frac{RSS}{\gamma_R} = \text{Residual Mean Square}$$

For Total Average

$$\sigma_T^2 = \frac{TSS}{\gamma}$$

D. Standard Error (SE)

For Judge 1

$$SE = \pm\sqrt{\frac{\sigma_R^2}{n_1}} = \pm\sqrt{\frac{RSS}{\gamma_R n_1}}$$

For Judge 2

$$SE = \pm\sqrt{\frac{\sigma_R^2}{n_2}} = \pm\sqrt{\frac{RSS}{\gamma_R n_2}}$$

For Total

$$SE = \pm\sqrt{\frac{\sigma_T^2}{n}} = \pm\sqrt{\frac{TSS}{\gamma n}}$$

E. Averages

Judge 1 (J_1)

$$\bar{J}_1 = \frac{\sum_{j=1}^{n_1} X_{1j}}{n_1}$$

Judge 2 (J_2)

$$\bar{J}_2 = \frac{\sum_{j=1}^{n_2} X_{2j}}{n_2}$$

Total (T)

$$\bar{T} = \frac{\sum_{j=1}^{n} X_{ij}}{n}$$

Appendix II

Computation of Performance Measures

Table 1: Number of References Retrieved and Judged Relevant

Question	Number Retrieved	Number Judged Relevant Judge 1	Judge 2	Number Judged Relevant or Marginal Judge 1	Judge 2
	$Y'_{1.}$	Y'_{11}		Y''_{11}	
1	8	8	7	8	7
2	18	7	16	16	18
3	18	1	6	16	18
4	23	2	15	4	22
5	-	-	-	-	-
6	3	3	3	3	3
7	16	7	2	11	2
8	8	0	6	0	6
9	2	2	1	2	2
10	-	-	-	-	-
11	2	2	2	2	2
12	2	2	2	2	2
13	-	-	-	-	-
14	-	-	-	-	-
15	43	19	26	26	29
16	-	-	-	-	-
17	1	1	1	1	1
18	218	16	19	54	85
19	40	0	0	1	3
20	2	2	2	2	2
21	16	5	16	13	-
22	62	16	9	3	60
23	25	10	8	19	19
24	183	141	158	177	180
25	18	10	17	10	17

Table 2: RECALL RATIOS

Question	Relevant		Combined	
	Judge 1	Judge 2	Judge 1	Judge 2
1	0.333	0.250	0.200	0.125
2	0.200	0.500	0.333	0.300
4	1.000	0.500	1.000	0.333
6	0.500	0.400	0.500	0.400
7	0.500	1.000	0.333	0.333
8	0.000	0.200	0.000	0.200
15	0.000	0.167	0.500	0.125
18	0.000	1.000	0.125	0.200
21	0.667	0.714	0.714	0.625
22	0.444	1.000	0.500	0.600
23	0.125	0.250	0.077	0.143
24	0.333	1.000	0.333	0.333
Average ± SE (per Judge)	0.295 ±0.018	0.668 ±0.018	0.373 ±0.008	0.299 ±0.008
Total Average ± SE	0.480 ±0.011		0.336 ±0.004	

Analysis of Variance

RECALL RATIO : RELEVANT

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square (Variance estimate)
Total	23	18813.501	--
Judges	1	2888.621	2888.621
Residual	22	15924.880	723.858

$$F = \frac{2888.621}{723.858} = 3.99$$

F (5% level of variance ratio) = 4.30

F (1% level of variance ratio) = 7.94

RECALL RATIO : COMBINED

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	23	6974.717	--
Judges	1	120.826	120.826
Residual	22	6853.891	311.541

Table 3: ESTIMATED TOTAL RELEVANT

Question	Relevant		Combined	
	Judge 1	Judge 2	Judge 1	Judge 2
1	24.00	28.00	40.00	56.00
2	35.00	32.00	48.00	26.67
4	2.00	30.00	4.00	66.00
6	6.00	7.50	6.00	7.50
7	14.00	2.00	33.00	6.00
8	0.00	30.00	0.00	30.00
15	0.00	159.00	52.00	232.00
18	0.00	19.00	432.00	425.00
21	7.50	22.40	18.20	
22	36.00	9.00	62.00	100.00
23	152.00	32.00	247.00	133.00
24	423.00	158.00	531.00	540.00
Average Rel. ± SE (per Judge)	58.29 ±26.99	44.08 ±26.99	122.77 ±52.11	147.47 ±54.43
Total Average Relevant ± SE	51.18 ±19.39		134.58 ±37.28	

Analysis of Variance

EST. TOTAL RELEVANT : RELEVANT

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	23	198429.65	--
Judges	1	6161.85	6161.85
Residual	22	192267.80	8739.45

EST. TOTAL RELEVANT : COMBINED

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	22	687866.37	--
Judges	1	3503.10	3503.10
Residual	21	684363.27	32588.73

Table 4: PRECISION RATIOS

Question	Relevant		Combined	
	Judge 1	Judge 2	Judge 1	Judge 2
1	1.000	0.875	1.000	0.875
2	0.389	0.889	0.889	1.000
3	0.056	0.333	0.889	1.000
4	0.087	0.652	0.174	0.957
6	1.000	1.000	1.000	1.000
7	0.438	0.125	0.688	0.125
8	0.000	0.750	0.000	0.750
9	1.000	0.500	1.000	1.000
11	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000
15	0.442	0.605	0.605	0.674
17	1.000	1.000	1.000	1.000
18	0.074	0.087	0.248	0.390
19	0.000	0.000	0.025	0.075
20	1.000	1.000	1.000	1.000
21	0.313	1.000	0.813	
22	0.258	0.145	0.500	0.968
23	0.760	0.320	0.760	0.760
24	0.770	0.863	0.967	0.984
25	0.556	0.944	0.556	0.944
Average ± SE (per Judge)	0.615 ±0.015	0.723 ±0.015	0.780 ±0.011	0.899 ±0.011
Total Average ± SE	0.668 ±0.007		0.842 ±0.006	

Table 4 Cont.

Analysis of Variance

PRECISION RATIO : RELEVANT

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	39	37175.846	--
Judges	1	430.730	430.730
Residual	38	36745.116	966.977

PRECISION RATIO : COMBINED

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	38	26789.125	--
Judges	1	866.500	866.500
Residual	37	25922.625	700.611

Continuation of Section 4 - Experimental data

from pages 24 and 25

4. 1. Question 1

4. 1 .1. Question

4. 1 .1.1. Original Statement Blast Furnaces and Tuyeres

4. 1 .1.2. Added Notes Any association of Tuyeres with blast furnaces, blast furnace practice or Iron-making.

4. 1 .1.3. UDC Analyst's Notes

Blast Furnaces - 669.162.2. In the most general sense, of description and broad view of operations.

Blast Furnace Tuyeres - 669.162.221.2. This is quite specifically "tuyeres", (normal, hearth tuyeres) Bosh Tuyeres is 669.162.221.8.

4. 1 .2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	669.162.221.2	C6691622212	8
B	669.162.221.8	C6691622218	0

(Note: All searches were run without regard to frequency of posting. A real information system would take this factor into account.)

4. 1 . 3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. (A or B)
2. (A$ or B$)

4. 1.4. Results and Analysis

4. 1.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	1	1	0	0
		A	B	C	D
	Judge 2	1	1	0	0
Retrieved by UDC only	Judge 1	7	7	0	0
		E	F	G	H
	Judge 2	7	6	0	1
Total Retrieved by UDC	Judge 1	8	8	0	0
		I	J	K	L
	Judge 2	8	7	0	1
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	7	2	2	3
		M	N	O	P
	Judge 2	7	3	4	0
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	8	3	2	3
		Q	R	S	T
	Judge 2	8	4	4	0

4. 1.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S}{9159(B+C}$
Judge 1	$\frac{1}{3}$	$\frac{1}{5}$	$\frac{8}{1/3}$	$\frac{8}{1/5}$	$\frac{8}{8}$	$\frac{8}{8}$	.0024	.0044
Judge 2	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{7}{1/4}$	$\frac{7}{1/8}$	$\frac{7}{8}$	$\frac{7}{8}$	.0031	.0061

4.1 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 5 |

Type 2: Non-relevant documents retrieved | Total = 1 |

Type	No	Indexing	Reason for Failure
1	1	669.168.228.2:533 Blast volume: Gas aero-dynamics	a. Concept not indexed. b. UDC classes inconsistently formed. 669.162.22... is "supply of blast to furnace". Subclasses 1/3 are formed according to apparatus used. Subclasses 4/8 are formed by a mixture of methods and process conditions, such as pressure, volume, and temperature.
1	2	669.162.221 Tuyeres and tuyere connections	a. Search formulation too specific. b. UDC class indexed has no identity separate from its subclasses. It appears to be only a convenience class for manual files.
1	3	669.162.267.4:662.87 Injection of fuel by blowing: Coal dust	a. Concept not indexed. Explicit in title. Process and material indexed, but apparatus not indexed.
1	4	669.162.238.21:669.162.222.24 Blast temperatures and temperature control apparatus: hot blast main, bustle pipes: insulation	a. Concept not explicit in document, but judged relevant by one judge.
1	5	669.162.283.2 Study of blast furnace reactions at the tuyere.	a. Search formulation did not account for this concept. b. UDC classes inconsistenly formed. 669.162.283 is a process-study of blast furnace reactions; subclass 2 refers to the apparatus which is the location of the process.
2	1	621.365.22+669.162.221.2+ 669.183.218.17/.18:62-52	a. No apparent reason for "non-relevant" judgement by one judge. Concept mentioned explicitly in abstract.

4. 2 Question 2

4. 2 .1. Question

4. 2 .1.1. Original Statement Retained Austenite

4. 2 .1.2. Added Notes Any reference or mention of retained austenite.

4. 2 .1.3. UDC Analyst's Notes

Retained Austenite - 669.112.227.343. This is quite specific. Transformation of retained austenite is 669.112.227.346.3.

4. 2 .2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	669.112.227.343	C669112227343	12
B	669.112.227.346.3	C6691122273463	6

4. 2 . 3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. (A or B)
2. (A$ or B$)

4.2 .4. Results and Analysis

4.2 .4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	3	1	2	0
		A	B	C	D
	Judge 2	3	3	0	0
Retrieved by UDC only	Judge 1	15	6	7	2
		E	F	G	H
	Judge 2	15	13	2	0
Total Retrieved by UDC	Judge 1	18	7	9	2
		I	J	K	L
	Judge 2	18	16	2	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	8	4	2	2
		M	N	O	P
	Judge 2	8	3	4	1
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	11	5	4	2
		Q	R	S	T
	Judge 2	11	6	4	1

4. .4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{1}{5}$	$\frac{3}{9}$	$\frac{7}{1/5}$	$\frac{16}{3/9}$	$\frac{7}{18}$	$\frac{16}{18}$	.0038	.0052
Judge 2	$\frac{3}{6}$	$\frac{3}{10}$	$\frac{16}{3/6}$	$\frac{18}{3/10}$	$\frac{16}{18}$	$\frac{18}{18}$	.0035	.0060

4. 2 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 4

Type 2: Non-relevant documents retrieved Total = 2

Type	No	Indexing	Reason for Failure
1	1	669.112.227.3:539.42 Transformation of austenite: Tensile strength	a. A broader concept, two hierarchical levels above the search specification, was indexed. The presence of retained austenite may be inferred from the subject, transformation of austenite. If this is true, the search should have included the broader concept.
1	2	669.14-422:621.785.796:539.4/.5 Steel-solid sections: quenching and tempering: physical properties	a. Search concept not indexed. Abstract says "...self-tempering does not break down all the austenite", implying that there is retained austenite.
1	3	669.14.018.252.3:539.4/.5: 669.293+669.295 High speed steels: physical properties: Niobium and titanium	a. Search concept not indexed. Mentioned in abstract.
1	4	669.15'24-194:669.112.227.3:538.6 Nickel alloy steels: Transformation of austenite: Effects of magnetic fields	a. Same as 4.2.5.1.1.
2	1	669.14.018.8:669.15-194.55: 669.112.227.346.3 Corrosion resistant steel: Martensitic alloys: Transformation of retained austenite	a. Judgement based on abstract, which did not mention or strongly imply retained austenite. Either (1) too little information given to judge or (2) indexing error.
2	2	669.14-131.2:669.112.227.346.3 Cold-worked steel: Transformation of retained austenite.	a. Possible indexing error. Abstract refers to transformation of austenite (669.112.227.3), with mention of retained austenite. b. Possibly too little information given to judge.

4.3 Question 3

4. 3 .1. Question

4. 3 .1.1. Original Statement Alloying Effects on Strain Aging and Internal Friction of Carbon Steels

4. 3 .1.2. Added Notes Effect of Cr on strain aging behavior of low carbon steel. Internal friction of low carbon steels. Influence of Mn and Cu on internal friction of low carbon steels. Strain aging of low carbon steels. Internal friction--Snoek mechanism elasticity.

4. 3 .1.3. UDC Analyst's Notes

This is best as a broad search under 539.67 for internal friction, and 621.785.797 for strain aging; connection by colon (:) with 669.26 for Cr, 669.3 for Cu, and 669.74 for Mn will narrow it.

4. 3 .2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	539.67	C53967	27
B.	621.785.797	C621785797	7
C	669.26	C66926	28
D	669.3	C6693	30
E	669.74	C66974	40

4. 3 . 3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. [(A + B) * (C + D + E)]
2. (A$ + B$)

4.3 .4. Results and Analysis

4.3 .4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	18	1	15	2
		E	F	G	H
	Judge 2	18	6	12	0
Total Retrieved by UDC	Judge 1	18	1	15	2
		I	J	K	L
	Judge 2	18	6	12	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	4	0	1	3
		M	N	O	P
	Judge 2	4	1	0	3
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	4	0	1	3
		Q	R	S	T
	Judge 2	4	1	0	3

4. 3.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	$\frac{1}{18}$	$\frac{16}{18}$	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	$\frac{6}{18}$	$\frac{18}{18}$	n.a.	n.a.

4. 3 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 1

Type 2: Non-relevant documents retrieved Total = 2

Type	No	Indexing	Reason for Failure
1	1	669.15'784:621.785.97:539.67 Iron-carbon alloys: [...]: internal friction	a. Recording or transcription error. 621.785.97 does not appear in the UDC Special Subject Edition for Metallurgy. Search called for 621.785.797.
2	1	621.762.8:621.785.797 After-treatment of sintered compacts: Ageing or temper-hardening combined with work hardening	a. Does not deal with carbon steels. Search statement too loose - required only strain ageing or internal friction.
2	2	669.12:548.53:548.4:539.67 iron: recrystallization: dislocations: internal friction	a. Same as 4.3.5.2.1.

4.4 Question 4

4. 4.1. Question

4. 4.1.1. Original Statement Joining of Thin SS or Ni-Alloy Sheets, strip or foil

4. 4 .1.2. Added Notes Fusion welding or resistance spot welding of thin stainless steel or nickel base alloy sheet, or strip, or foil.

4. 4 .1.3. UDC Analyst's Notes Electric fusion welding is 621.791.753, submerged arc welding 621.791.753.5, and welding with protective atmospheres is 621.791.753.9: resistance spot-welding is 621.791.763.1. Stainless steels are 669.14.018.8, where the composition is not specified. When it is, as in a Cr-Ni stainless, it would have the number 669.15'24'26-194.56, to denote an austenitic (-194.56) alloy steel containing Cr or Ni: other elements, such as Mo, would cause the insertion of '28 after the

(cont. in bottom box)

4. 4 .2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	621.791.753	C621791753	75
B	621.791.763.1	C6217917631	4
C	669.14	C66914	2073
D	.018.8	X188	393
E	669.15'24	C66915Y24	139
F	669.245	C669245	3
G	-415	W415	101
H	-416	W416	11
I	-418	W418	18

4. 4 . 3. Encoded Logical Statements (condensed form)

(+ = or, * = and, $ = truncation)

1. {(A + B) * {[(C*D$) + E + F] * (G$ + H$ + I$)}}

2. {(A$ + B$) * {[(C$ * D$) + E$ + F$] * (G$ + H$ + I$)}}

3. {621.791.7$ * [(C$ * D$) + E$ + F$]}

'26. Nickel alloys, unspecified, are 669.245, and when the composition is given, e.g. a Ni-Cr alloy, denoted by 669.245'26. The shape is denoted by -415, for thin plate and sheet, -416 for very thin plate and foil, and -418 for strips. Various combinations must therefore be made, as for example:

669.14.018.8-416:621.791.763.1 Spot welding of stainless steel foil.

4.4.4. Results and Analysis

4.4.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	1	1	0	0
		A	B	C	D
	Judge 2	1	1	0	0
Retrieved by UDC only	Judge 1	22	1	2	19
		E	F	G	H
	Judge 2	22	14	7	1
Total Retrieved by UDC	Judge 1	23	2	2	19
		I	J	K	L
	Judge 2	23	15	7	1
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	2	0	0	2
		M	N	O	P
	Judge 2	2	1	1	0
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	3	1	0	2
		Q	R	S	T
	Judge 2	3	2	1	0

4.4.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\,B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{1}{1}$	$\frac{1}{1}$	$\frac{2}{1/1}$	$\frac{4}{1/1}$	$\frac{2}{23}$	$\frac{4}{23}$	.0002	.0004
Judge 2	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{15}{1/2}$	$\frac{22}{1/3}$	$\frac{15}{23}$	$\frac{22}{23}$	.0033	.0072

4. 4 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 1

Type 2: Non-relevant documents retrieved Total = 19

Type	No	Indexing	Reason for Failure
1	1	669.14.018.8:621.791.762.1+ 621.791.763.1 Stainless steel: Butt welding + Spot welding	a. Document record keypunched correctly, but apparently did not enter file during file creation. Should have been retrieved.
2	1-19	(various)	a. Search statement too loose. The requirement for thin sheet, strip, or foil was dropped. However, if it had been retained, one of the two documents which both judges agreed was relevant would not have been retrieved.

4.5 Question 5

4.5 .1. Question

4.5 .1.1. Original Statement Effect of Alloying Additions on the Austenitic Properties of Steels

4.5 .1.2 Added Notes Effect of small additions of aluminum, niobium (columbium), vanadium, titanium, and zirconium on the austenitic grain size, grain coarsening temperature, mechanical properties, forgeability and impact properties of plain carbon bar, rod, wire and tube steels in the presence of varying amounts of nitrogen and sulfur. Solution temperature of the oxides, carbides, nitrides, and sulfides of the above elements in austenite. Solubility product of aluminum, columium, chromium, vanadium, titanium, and zirconium oxides, carbides, nitrides, and sulfides in austenite as a function of temperature.

4.5 .1.3. UDC Analyst's Notes

This is a severe test for any scheme of classification or any thesaurus or controlled vocabulary. However, as the "definition" refers, largely, to austenite 669.112.227.1 provides a good general handle. Abnormal grain size will be denoted by -175, and the study of grain size, as a metallographic technique, by 620.186.82; mechanical properties should be sought either as a general subject at 539.4/.5, or under individual properties. Forgeability is best sought under 621.733.01. The aspect of "bar, rod, wire or tube" are hyphen numbers and according to my practice, would be found at 669.14-422.1, 669.14-422.2, 669.14-426, and 669.14-462 respectively. The solution and solubility aspects should be found at 541.8, solution and solubility in general. The various elements affecting any of the properties will have been classified under their numbers from 669, the oxides, carbides, etc., by means of the numbers from 546, e.g. 669.71, aluminium, 546.621'171.1,aluminium nitride, 669.296 zirconium, 546.831'261 zirconium carbide.

4.5 .2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	669.71...	C66971$	61
B	669.29...	C66929$	91
C	669...	C669$	very many
D	620.186.82...	C62018682$	10
E	539.4...	C5394$	848
F	539.5...	C5395$	286
G	620.17...	C62017$	369
H	669.14...	C66914$	very many
I	621.733...	C621733$	24
J	620.178.7...	C6201787$	55
K	541.8...	C5418$	19
L	669.112.227.1...	C6691122271$	46
M	546.621	C546621	1
N	546.621'171.1	C546621Y1711	0
O	546.621'261	C546621Y261	0
P	546.621'221	C546621Y221	0
Q	546.882	C546882	0
R	546.882'171.1	C546882Y1711	0
S	546.882'261	C546882Y261	2
T	546.882'221	C546882Y221	1
U	546.881	C546881	0
V	546.881'171.1	C546881Y1711	0
W	546.881'261	C546881Y261	3
X	546.881'221	C546881Y221	0
Y	546.821	C546821	1
Z	546.821'171.1	C546821Y1711	0
AA	546.821'261	C546821Y261	2
AB	546.821'221	C546821Y221	1
AC	546.831	C546831	0
AD	546.831'171.1	C546831Y1711	0
AE	546.831'261	C546831Y261	0
AF	546.831'221	C546831Y221	0
AG	-175...	W175$	4
AH	-31...	W31$	48
AI	-422...	W422$	24
AJ	-426...	W426$	57
AK	-462...	W462$	117
AL	.01...	X1$	very many
AM	.018.2...	X182$	487

4.5 .3. Encoded Logical Statements (condensed form)

(+ = or, * = and, $ = truncation)

1. {(A + B) * [(C * AG) + D + E + F + G + (H * AM) + (I * AL) + J] *
[C * (AI + AJ + AK)]}

2. {K * L * {[AH * (M + Q + U + Y + AC)] + N + O + P + R + S + T + V + W
+ X + Z + AA + AB}}

4.5.4. Results and Analysis

4.5.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	0	0	0	0
		E	F	G	H
	Judge 2	0	0	0	0
Total Retrieved by UDC	Judge 1	0	0	0	0
		I	J	K	L
	Judge 2	0	0	0	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	6	4	1	1
		M	N	O	P
	Judge 2	6	4	1	1
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	6	4	1	1
		Q	R	S	T
	Judge 2	6	4	1	1

4.5.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

4. 5 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 4 |

Type 2: Non-relevant documents retrieved | Total = 0 |

Type	No	Indexing	Reason for Failure
1	1	669.15-194:539.4/.5:669.293 Alloy steels: physical properties: niobium	a. Concept "austenite properties" or "austenite" not indexed. Not mentioned explicitly in abstract.
1	2	669.14:620.192.45:546.28-31 Steel: inclusions: Silicon oxide	a. Same as 4.5.5.1.1.
1	3	669.14-122+669.14-153.65: 669.292/.293:539.4/.5 Rolled + normalized annealed steel : vanadium + niobium: physical properties	a. Same as 4.5.5.1.1.
1	4	669.15-194:539.4/.5:669.292 Alloy steels: physical properties: vanadium	a. Same as 4.5.5.1.1.

4. 6 Question 6

4.6 .1. Question

4.6 .1.1. Original Statement Tubes--Cold Drawing

4.6 .1.2. Added Notes Cold drawing or cold rolling of tubes of any type of steel.

4.6 .1.3. UDC Analyst's Notes The definition refers to cold rolling or cold drawing. The former is 621.774.35.016.3, the latter is 621.774.37.016.3.

4.6 .2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	621.774.35	C62177435	28
B	621.774.37	C62177437	5
C	621.774.3$	C6217743$	60
D	.016.3...	X163$	90

4.6 .3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. [(A + B) * D]
2. [(A$ + B$) * D]
3. (C * D)

4. 6.4. Results and Analysis

4. 6.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1 Judge 2	2 A 2	2 B 2	0 C 0	0 D 0
Retrieved by UDC only	Judge 1 Judge 2	1 E 1	1 F 1	0 G 0	0 H 0
Total Retrieved by UDC	Judge 1 Judge 2	3 I 3	3 J 3	0 K 0	0 L 0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1 Judge 2	4 M 4	2 N 2	0 O 1	2 P 1
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1 Judge 2	6 Q 6	4 R 4	0 S 1	2 T 1

4.6 .4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{2}{4}$	$\frac{2}{4}$	$\frac{3}{2/4}$	$\frac{3}{2/4}$	$\frac{3}{3}$	$\frac{3}{3}$	.0007	.0007
Judge 2	$\frac{2}{4}$	$\frac{2}{5}$	$\frac{3}{2/4}$	$\frac{3}{2/5}$	$\frac{3}{3}$	$\frac{3}{3}$	.0007	.0008

4. 6 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 2 |

Type 2: Non-relevant documents retrieved | Total = 0 |

Type	No	Indexing	Reason for Failure
1	1	621.774.37.074 Drawn tube manufacture - formers	a. The indexing referred only to the process and apparatus, although the process condition "cold" (.016.3) is mentioned in the title. b. The UDC auxiliary notation mixes apparatus and process conditions in the .0 auxiliaries applicable here. It is awkward and possibly ambiguous to use two .0 auxiliaries on the same main class number, e.g. 621.774.37.016.3.074.
1	2	621.774.35 Rolled tube manufacture	a. Same as 4.6.5.1.1.a.

4.7 Question 7

4.7 .1. Question

4.7 .1.1. Original Statement Plug Mill Tube Making

4.7 .1.2. Added Notes Rolling of steel seamless tubes in plug rolling mill and rolling conditions including torque, stresses, strains, roll forces, and forces acting upon mandrel.

4.7 .1.3. UDC Analyst's Notes

I take this to be rolling over a plug set in the roll gap, for the further expansion of already pierced tubes. This will therefore be denoted by 621.774.35: the auxiliary aspects, such as torque, roll-force, etc., will be indicated by adding subdivisions of .01, e.g. .011, stress and flow of material, .014.3, roll pressure.

4.7 .2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	621.774.35	C62177435	28
B	.01...	X1$	very many
C	621.774.3...	C6217743$	68

4.7 .3. Encoded Logical Statements (condensed form)

(+ = or, * = and, $ = truncation)

1. (A * B)
2. (A$ * B)
3. (C * B)

4.7.4. Results and Analysis

4.7.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	1	1	0	0
		A	B	C	D
	Judge 2	1	1	0	0
Retrieved by UDC only	Judge 1	15	6	4	5
		E	F	G	H
	Judge 2	15	1	0	14
Total Retrieved by UDC	Judge 1	16	7	4	5
		I	J	K	L
	Judge 2	16	2	0	14
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	4	1	1	2
		M	N	O	P
	Judge 2	4	0	2	2
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	5	2	1	2
		Q	R	S	T
	Judge 2	5	1	2	2

4.7.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\,B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{7}{1/2}$	$\frac{11}{1/3}$	$\frac{7}{16}$	$\frac{11}{16}$	.0015	.0036
Judge 2	$\frac{1}{1}$	$\frac{1}{3}$	$\frac{2}{1/1}$	$\frac{2}{1/3}$	$\frac{2}{16}$	$\frac{2}{16}$	.0002	.0007

4. 7 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 1

Type 2: Non-relevant documents retrieved Total = 14

Type	No	Indexing	Reason for Failure
1	1	621.774.35.06 Rolled tube manufacture - mill design and construction	a. Search concept .01... - factors influencing the process - was not indexed. No specific factors are mentioned in the abstract. The search specification was too tight in requiring .01... to be present. Specification of 621.774.35... alone would have been adequate to retrieve this document. However, see 4.7.5.2.3, below. b. The UDC .0 auxiliary mixes (1) principles and influencing factors (.01...), (2) preparation of materials (.02...), and (3) mill design and construction, i.e. apparatus (.06...), making it awkward to index a paper which refers to several of these aspects of rolled tube manufacture.
2	1	621.774.375 and others	a. One version of the search was too loose. Judge indicated that the wrong process is involved.
2	2	621.774.37 and others	a. Same as 4.7.5.2.1.
2	3	621.774.35:629.118.3.012.3	a. Technically an example of false coordination. The .0 auxiliary specified was attached to a number other than 621.774.35. However, if the .01 auxiliary was not actually required (see 4.7.5.1.1.a.), then there is no apparent reason for a judgement of non-relevance. b. The judge noted "wrong process" on his judgement form. There is no way to specify a plug rolling mill as distinct from other rolling mills. Therefore, it appears that the UDC is deficient in this case.
2	4	621.774.352.011 and others	a. No apparent reason for judgement of non-relevance. Judge noted "wrong process". Same as 4.7.5.2.3.b.
2	5	621.774.35 " "	a. Same as 4.7.5.2.3.a and b.
2	6	621.774.37.016.3 " "	a. Same as 4.7.5.2.1.
2	7	621.774.35 " "	a. Same as 4.7.5.2.3b.
2	8	621.774.3.019 " "	a. Same as 4.7.5.2.1.
2	9	621.774.35.019 " "	a. Same as 4.7.5.2.3b.
2	10	621.774.35.016.2 " "	a. Same as 4.7.5.2.3b.
2	11	621.774.35.011 " "	a. Same as 4.7.5.2.3b.
2	12	621.774.77 " "	a. Same as 4.7.5.2.1.
2	13	621.774.35.014.2 " "	a. Same as 4.7.5.2.3b.
2	14	621.774.35 " "	a. Same as 4.7.5.2.3b.

4.8 Question 8

4.8 .1. Question

4.8 .1.1. Original Statement Hydrogen Embrittlement of Martensitic and/or Austensitic Stainless Steels, and/or Maraging Steels.

4.8 .1.2. Added Notes Embrittlement (from any cause, including hydrogen), and associated or occurring in any austenitic, martensitic or ferritic stainless steel, or in maraging steel.

4.8 .1.3. UDC Analyst's Notes
Embrittlement is denoted by 539.56; if specifically to hydrogen, 669.788 will be attached by colon (:). Austenitic, martensitic and ferritic stainless steels require -194.56, -194.55, or -194.57 respectively to be added to composition e.g. 669.15'26-194.55, martensitic chromium steels.

4.8 .2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	539.56	C53956	167
B	669.788	C669788	113
C	669.15...	C66915$	very many
D	-194.55...	W19455$	21
E	-194.56...	W19456$	155
F	-194.57...	W19457$	27

4.8 .3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. [A * B * C * (D + E + F)]

2. [A$ * B$ * C * (D + E + F)]

3. [A$ * C * (D + E + F)]

4. 8.4. Results and Analysis

4. 8.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	1	0	0	1
		A	B	C	D
	Judge 2	1	1	0	0
Retrieved by UDC only	Judge 1	7	0	0	7
		E	F	G	H
	Judge 2	7	5	0	2
Total Retrieved by UDC	Judge 1	8	0	0	8
		I	J	K	L
	Judge 2	8	6	0	2
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	4	1	0	3
		M	N	O	P
	Judge 2	4	4	0	0
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	5	1	0	4
		Q	R	S	T
	Judge 2	5	5	0	0

4. 8.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{0}{1}$	$\frac{0}{1}$	$\frac{0}{0/1}$	$\frac{0}{0/1}$	$\frac{0}{8}$	$\frac{0}{8}$	n.a.	n.a.
Judge 2	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{6}{1/5}$	$\frac{6}{1/5}$	$\frac{6}{8}$	$\frac{6}{8}$	.0033	.0033

4. 8 .5. Failure analysis

Type 1: Known relevant documents not retrieved — Total = 4

Type 2: Non-relevant documents retrieved — Total = 8

Type	No	Indexing	Reason for Failure
1	1	669.15'26-194:669.14.018.8: 669.14.018.29:620.194.2 Chromium alloy steels: Stainless steel: structural steel: stress corrosion	a. "Embrittlement" not indexed and present in abstract only as possibly implied in "stress corrosion cracking". One judge picked this as relevant, the other as non-relevant. In sum, a subjective judgement which could not be accounted for by the system seems to have been in play.
1	2	669.15'24'26'295-194:620.187 Nickel-chromium-titanium alloy steels: electron microscopic investigation	a. "Embrittlement" not indexed. Mentioned in abstract. Indexing failure.
1	3	669.14.018.8:539.56:669.788 Stainless steel: Brittleness: Hydrogen	a. Search specification too tight. b. Indexer and searcher used partially synonymous expressions. Indexer used 669.14.018.8 - corrosion-resistant steels (without reference to structure or composition); searcher used 669.15-194.5... alloy steels according to structure. This may be considered to be (1) An indexing error - a steel of specific composition (type 410 SS) is mentioned in the title, but the composition is not indexed; (2) A search error - the search statement should have taken the possible alternatives into account; or (3) A defect in the structure of UDC to allow such ambiguity.
1	4	669.14.018.8:621.785.78 Stainless steel: ageing	a. "Embrittlement" is not indexed, although "brittleness" is mentioned in the abstract. Hydrogen is not mentioned. Could be considered either (1) An indexing error (2) A questionable judgement, as in 4.8.5.1.1.
2	1-8		Search specification too loose. All of these deal with embrittlement of the requested steels, but without mentioning hydrogen as the cause of the embrittlement. One judge said all eight are non-relevant. The other judge selected six of the eight as relevant.

4. 9 Question 9

4.9 .1. Question

4.9 .1.1. Original Statement Additing Nitrogen to Austenitic SS; Effects of N

4.9 .1.2. Added Notes Methods of additing nitrogen to austenitic stainless steels as an alloying agent. Effect of nitrogen on room temperature and high temperature mechanical properties, corrosion resistance, weldability and formability of austenitic stainless steels.

4.9 .1.3. UDC Analyst's Notes

See notes to Question 4 for austenitic stainless steel. The addition of :669.786 denotes some effect of nitrogen. The third aspects, e.g. corrosion resistance can be added by colon (:) though in general, I would denote them as the second concept. e.g. 669.15'24'26-194.56: 621.791.753:669.786 the influence of nitrogen on the electric arc welding of austenitic stainless steel.

4.9 .2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	669.786	C669786	45
B	669.15...	C66915$	very many
C	-194.56...	W19456$	155

4.9 .3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. (A * B * C)

2. (A$ * B * C)

4. 9.4. Results and Analysis

4. 9.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	2	2	0	0
		E	F	G	H
	Judge 2	2	1	1	0
Total Retrieved by UDC	Judge 1	2	2	0	0
		I	J	K	L
	Judge 2	2	1	1	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	22	3	4	15
		M	N	O	P
	Judge 2	22	8	4	10
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	22	3	4	15
		Q	R	S	T
	Judge 2	22	8	4	10

4. 9.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	$\frac{2}{2}$	$\frac{2}{2}$	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	$\frac{1}{2}$	$\frac{2}{2}$	n.a.	n.a.

4. 9 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 8

Type 2: Non-relevant documents retrieved | Total = 0

Type	No	Indexing	Reason for Failure
1	1	669.15-194.56:669.14.018.8-157.8: 621.785.78 Austenititic alloy steels: age hardened stainless steel: ageing	a. "Nitrogen" not indexed, but mentioned in abstract. However, carbon-nitrogen steel would have been indexed as 669.15'786 and this would not have been retrieved by a request for 669.786 in the present version of the retrieval system.
1	2	669.15'24'26'74-194.3-15: 539.4/.5:669.292+669.786 Heat treated nickel-chromium-manganese high alloy steels: physical properties: vanadium: nitrogen	a. "Austenitic" (-194.56) not indexed and not present in the abstract. Either (1) Search specification too tight, or (2) Questionable judgement of relevance.
1	3	669.15'24'26-194:620.194.2 Nickel-chromium alloy steels: Stress corrosion	a. "Nitrogen" not indexed, but mentioned in the abstract. b. Type of steel was indexed two hierarchical levels above that called for in the search specification. "Austenitic" is not mentioned specifically as the type of steel alloy.
1	4	669.14.018.8: 669.15'26'3'782'786-194:620.186 Stainless steel: chromium-copper-silicon-nitrogen alloy steels: microscopic examination	a. UDC notation involving nitrogen (669.15....'786...) cannot be processed properly by present retrieval system. b. Same as 4.9.5.1.3b.
1	5	669.141.241.2:669.14.018.262: 620.192.45:620.187 Killed steel: Soft steels for drawing: inclusions: electron microscopic investigation	a. Nitrogen not indexed, but mentioned in the abstract. b. "Austenitic" not indexed or mentioned as the type of steel alloy. Questionable judgement of relevance by one judge.
1	6	669.017.1 Alloy systems	a. Neither "nitrogen" nor "austenitic SS" were indexed. The indexing was too shallow and general.
1	7	669.14.018.8:539.415:669.786 Stainless steel: resistance to shear: nitrogen	a. Indexer used a partial synonym, 669.14.018.8 of the term specified for the search, 669.15-194.56. As explained under 4.8.5.1.3, this may be looked at as (1) An indexing error; (2) A search analysis error; or (3) A defect in the UDC.

4. 9 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 8 |

Type 2: Non-relevant documents retrieved | Total = 0 |

Type	No	Indexing	Reason for Failure
1	8	669.14.018.8: 669.15'24'26'74'786-194 Stainless steel: nickel-chromium-manganese-nitrogen alloy steels.	a. Same as 4.9.5.1.4a. b. Same as 4.9.5.1.3b.

4.10 Question 10

4.10.1. Question

4.10.1.1. Original Statement Spheroidization kinetics of pearlite in steels

4.10.1.2. Added Notes Spheroidization kinetics of pearlite in carbon and alloy steels

4.10.1.3. UDC Analyst's Notes

Spheroidization will come under 621.785.37, processes not involving phase transformation. Alloy steels as such is 669.15-194, unless specific elements are mentioned, as 669.15'26'28-194 chromium molybdenum steels. Kinetics is not easily classified, and I suggest 536.7 thermodynamics, and possibly worth a search at 541.124, generalities of chemical dynamics.

4.10.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	621.785.37	C62178537	1
B	669.15...	C66915$	very many
C	-194...	W194$	958
D	536.7	C5367	17
E	541.124	C541124	42

4.10.3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. [A * B * C * (D + E)]
2. [A$ * B * C * (D$ + E$)]
3. (A$ * B * C)

4.10.4. Results and Analysis

4.10.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1 Judge 2	0 A 0	0 B 0	0 C 0	0 D 0
Retrieved by UDC only	Judge 1 Judge 2	0 E 0	0 F 0	0 G 0	0 H 0
Total Retrieved by UDC	Judge 1 Judge 2	0 I 0	0 J 0	0 K 0	0 L 0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1 Judge 2	10 M 10	1 N 2	3 O 2	6 P 6
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1 Judge 2	10 Q 10	1 R 2	3 S 2	6 T 6

4.10.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

4.10 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 2

Type 2: Non-relevant documents retrieved Total = 0

Type	No.	Indexing	Reason for Failure
1	1	669.15'782-194.54:669.112.241: 620.186.1 Hypereutectoid silicon steel alloys : beginning of graphite precipitation in the Fe-C system: identification of phases by microscopic investigation	a. "Spheroidization" was not indexed, but is mentioned in the abstract. Indexing failure.
1	2	621.777.02:621.785.37 Pretreatment of the workpiece in extrusion: processes not involving phase transformation (including spheroidization)	a. The type of steel was not indexed. b. The search statement was too tight. A search for 621.785.37 would have retrieved this document, the only one posted to this class.

4.11 Question 11

4.11.1. Question

4.11.1.1. Original Statement Joining Cast Iron to Steel

4.11.1.2. Added Notes Joining (welding, brazing, soldering, adhesive bonding) of cast iron to steel.

4.11.1.3. UDC Analyst's Notes

All such processes as soldering, brazing and welding are to be found in the subdivision of 621.791, e.g. 621.791.35, soft soldering, 621.791.36, brazing, 621.791.753.9, submerged arc welding. Articles covering more than one of the processes will be under 621.791 itself. "Cast Iron to Steel" is not an easy concept for any one. 669.131+669.14 is nearest in the UDC.

4.11.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	621.791	C621791	74
B	621.791...	C621791$	358
C	669.131	C669131	16
D	669.14	C66914	2073
E	621.79...	C62179$	517
F	669.13...	C66913$	369
G	669.15...	C66915$	very many

4.11.3. Encoded Logical Statements (condensed form)

(+ = or, * = and, $ = truncation)

1. (A * C * D)

2. (B * C$ * D$)

3. [E * F * (D$ + G)]

4.11.4. Results and Analysis

4.11.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	2	2	0	0
		E	F	G	H
	Judge 2	2	2	0	0
Total Retrieved by UDC	Judge 1	2	2	0	0
		I	J	K	L
	Judge 2	2	2	0	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	3	1	0	2
		M	N	O	P
	Judge 2	3	1	0	2
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	3	1	0	2
		Q	R	S	T
	Judge 2	3	1	0	2

4.11.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	$\frac{2}{2}$	$\frac{2}{2}$	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	$\frac{2}{2}$	$\frac{2}{2}$	n.a.	n.a.

4.11 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 1 |

Type 2: Non-relevant documents retrieved | Total = 0 |

Type	No	Indexing	Reason for Failure
1	1	669.14.018.29:621.792.5/.8 Structural steel: gas, thermit, electric, and combined forms of welding	a. "Cast iron" not indexed, but mentioned in abstract.

4. 12 Question 12

4.12.1. Question

4.12.1.1. Original Statement Heat Treatment of Steels with Ultrasonics

4.12.1.2. Added Notes Heat treating any steel using ultrasonics

4.12.1.3. UDC Analyst's Notes

The heat treatment process should be specified; if not, search should be made in 621.785 itself and all its subdivisions, for material additionally classified with 534.29-8. This number means "The Effect of Ultrasonic Vibrations".

4.12.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	621.785	C621785	129
B	534.29	C53429	27
C	-8...	W8$	64

4.12.3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. (A * B * C)
2. (A$ * B$ * C)

4.12.4. Results and Analysis

4.12.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	2	2	0	0
		E	F	G	H
	Judge 2	2	2	0	0
Total Retrieved by UDC	Judge 1	2	2	0	0
		I	J	K	L
	Judge 2	2	2	0	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	3	0	1	2
		M	N	O	P
	Judge 2	3	1	0	2
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	3	0	1	2
		Q	R	S	T
	Judge 2	3	1	0	2

4.12.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	$\frac{2}{2}$	$\frac{2}{2}$	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	$\frac{2}{2}$	$\frac{2}{2}$	n.a.	n.a.

4.12 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 1

Type 2: Non-relevant documents retrieved Total = 0

Type	No	Indexing	Reason for Failure
1	1	669.12:620.186.84:534.29-8 Pure iron: grain boundaries: ultrasonics	a. Concept "heat treatment" was not indexed, but mentioned in title and abstract.

4.13 Question 13

4.13.1. Question

4.13.1.1. Original Statement Impurity Effect on Mechanical Properties of Ship Plate

4.13.1.2. Added Notes Influence of S, P, O, C, Cr_2O_3, Al_2O_2, TiO_2 and other impurities on all mechanical properties of plates used for ship hulls and submarines.

4.13.1.3. UDC Analyst's Notes

This is another enquiry which is both very general and very specific. As in Question 5, the Individual properties if not recoverable at 539.4/.5 (when coloned to 669.14.018.293-414, ship building steels, in plate form) should be sought separately.

4.13.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	669.14	C66914	2073
B	.018.293...	X18293$	5
C	-414...	W414$	34
D	539.4	C5394	445
E	539.5	C5395	1

4.13.3. Encoded Logical Statements (condensed form)

(+ = or, * = and, $ = truncation)

1. [A * B * C * (D + E)]

2. [A$ * B * C * (D$ + E$)]

3. (A$ * B * C)

4.134. Results and Analysis

413.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	0	0	0	0
		E	F	G	H
	Judge 2	0	0	0	0
Total Retrieved by UDC	Judge 1	0	0	0	0
		I	J	K	L
	Judge 2	0	0	0	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	6	1	0	5
		M	N	O	P
	Judge 2	6	0	1	5
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	6	1	0	5
		Q	R	S	T
	Judge 2	6	0	1	5

4.13.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

4. 13.5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 1 |

Type 2: Non-relevant documents retrieved | Total = 0 |

Type	No	Indexing	Reason for Failure
1	1	669.15'24'26'28'292-194: 621.791.011:539.42 Nickel-Chromium-Molybdenum-Vanadium alloy steels: Weldability : Tensile strength	a. The steel was not indexed according to intended use. The use was not mentioned in the abstract. This is an example of inferred relevance, based on the judge's experience. Such documents can only be retrieved by running looser searches with the expectation of retrieval of larger numbers of non-relevant documents in addition to some relevant documents. b. The steel was not indexed according to the shape or form of the article, although "plate" is mentioned along with several other forms. Indexing failure.

4.14 Question 14

4.14.1. Question

4.14.1.1. Original Statement Iron Ore Pellets

4.14.1.2. Added Notes None.

4.14.1.3. UDC Analyst's Notes

622.341.1	Iron Ore
622.341.11	Magnetite
622.341.12	Haematite

Add -188.36 for "in the form of pellets"

4.14.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	622.341.1	C6223411	286
B	622.341.11	C62234111	18
C	622.341.12	C62234112	11
D	622.341...	C622341$	332
E	-188.36...	W18836$	0*

*Note: Searches were run according to UDC analyst's notes, without knowledge of frequency of posting. The search specification precluded retrieval of any documents.

4.14.3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. [(A + B + C) * E]
2. (D * E)

4. 144. Results and Analysis

4.14.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	0	0	0	0
		E	F	G	H
	Judge 2	0	0	0	0
Total Retrieved by UDC	Judge 1	0	0	0	0
		I	J	K	L
	Judge 2	0	0	0	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	21	12	0	9
		M	N	O	P
	Judge 2	21	13	3	5
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	21	12	0	9
		Q	R	S	T
	Judge 2	21	13	3	5

4.14.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

4. 14.5. Failure analysis

Type 1: Known relevant documents not retrieved **Total = 13**

Type 2: Non-relevant documents retrieved **Total = 0**

Type	No	Indexing	Reason for Failure
1	1	622.785.5:622.788.36 Sintering using Dwight-Lloyd sintering machine: manufacture of rolled pellets (pelletizing)	a. The UDC provides different class numbers for pellets as the shape or form of article (auxiliary -188.36) and for the processes of pelletizing by extrusion (622.788.34) and by use of a rotating drum for agglomeration (621.788.36). The abstract refers to both the process and to the properties of the pellets thus formed. The search formulation specified only the form of article. Therefore, this failure may be considered to be (1) An indexing error; or (2) a search analysis error; or (3) a defect in the UDC structure.
1	2	622.341.1-185:669.046.546.2 Sintered iron ores: desulfurization during melting	a. "Pellets" as the shape of article was not indexed, although it is specifically mentioned in the title
1	3	622.341.1 Iron ores	a. "Pelletizing" as a process is not indexed, although it is specifically mentioned in the title. b. Since the search analyst did not specify the numbers which represent the process, the document would not have been retrieved even if it had been indexed fully. Therefore, this is also a search analysis error.
1	4	622.788 Manufacture of shaped ore agglomerates (briquettes, pellets, and nodules)	a. A search analysis error. The title of the document is "Pelletizing".
1	5	669.162.26:622.341.1-188 Operation of blast furnaces: iron ores in the form of shaped agglomerates	a. The concept indexed (-188 = shaped agglomerates) is two hierarchical levels above that specified for the search (-188.36 = pellets). The abstract refers only to pellets. Indexing failed to be as specific as possible.
1	6	622.341.11-188:621.786.5: 669.046.546.2 Magnetite in the form of shaped agglomerates: [see b]: desulfurization	a. Same as 4.14.5.1.5. b. 621.786.5 does not exist as a UDC class number. The intention must have been 621.785.6, hardening. Although it did not prevent retrieval of this document, it is an error in transcription in the indexing process.
1	7	622.341.12:669.094.1 Haematite: Reduction by hydrogen	a. "Pellets" not indexed, but mentioned in abstract.

4. 14.5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 13 |

Type 2: Non-relevant documents retrieved | Total = 0 |

Type	No	Indexing	Reason for Failure
1	8	622.788:536.24+539.217.4 Manufacture of shaped ore agglomerates: Heat conduction, heat transfer + permeability to gases	a. The document deals with gas and heat flow through a bed of iron ore pellets during their manufacture. This is a good example of the problem of separate classes for manufactured articles and the processes by which they are manufactured. See 4.14.5.1.1a (1, 2, 3).
1	9	622.341.1-188:66.096.5:669.094.2 Iron ore in the form of shaped agglomerates: Fluidization: Reduction by agents other than hydrogen	a. Same as 4.14.5.1.5.
1	10	622.341.1-188:66.046.5 Iron ore in the form of shaped agglomerates: fusion, melting, smelting	a. Same as 4.14.5.1.5.
1	11	622.788 Manufacture of shaped ore agglomerates	a. Same as 4.14.5.1.4.
1	12	622.341.1:622.788 Iron ore: manufacture of shaped ore agglomerates	a. Same as 4.14.5.1.1.
1	13	622.341.1-188:622.782.6 Iron ore in the form of shaped agglomerates: roasting in rotary furnaces	a. Same as 4.14.5.1.5.

4. 15 Question 15

4.15.1. Question

4.15.1.1. Original Statement The Effect of Cr-Ni-Cu-P on Atmospheric Corrosion

4.15.1.2. Added Notes The effect of any material, alloying addition or the like on atmospheric corrosion, scaling, rusting, oxidation, etc.

4.15.1.3. UDC Analyst's Notes This is remarkably vague, and the definition does not clarify it. Numbers for all the types of corrosion can be found at 620.193, e.g. 620.193.2 atmospheric corrosion. 620.193.53 effect of combustion gases. 620.193.54 effect of hot oxygen on oxidising gases. 669.26 Chromium. 669.24 nickel. 669.3 copper. 669.779 phosphorus.

4.15.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	620.193.2...	C6201932$	71
B	669.26...	C66926$	62
C	669.24...	C66924$	72
D	669.3...	C6693$	42
E	669.779...	C669779$	17

4.15.3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. [A * (B + C + D + E)]

2. (A)

4.15.4. Results and Analysis

4.15.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	1	0	1	0
		A	B	C	D
	Judge 2	1	1	0	0
Retrieved by UDC only	Judge 1	42	19	6	17
		E	F	G	H
	Judge 2	42	25	3	14
Total Retrieved by UDC	Judge 1	43	19	7	17
		I	J	K	L
	Judge 2	43	26	3	14
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	19	1	0	18
		M	N	O	P
	Judge 2	19	5	2	12
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	20	1	1	18
		Q	R	S	T
	Judge 2	20	6	2	12

4.15.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{0}{1}$	$\frac{1}{2}$	$\frac{19}{0/1}$	$\frac{26}{1/2}$	$\frac{19}{43}$	$\frac{26}{43}$	n.a.	.0028
Judge 2	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{26}{1/6}$	$\frac{29}{1/8}$	$\frac{26}{43}$	$\frac{29}{43}$	.0085	.0253

4. 15 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total =

Type 2: Non-relevant documents retrieved | Total =

Type	No	Indexing	Reason for Failure
2	3	620.193.27 Corrosion by sea water	a. Same as 4.15.5.2.1.
2	4	669.12:620.193.2 Iron: atmospheric corrosion	a. Same as 4.15.5.2.1.
2	5	620.197.5:620.193.27 Protection of materials by electrolytic processes: corrosion by sea water	a. Same as 4.15.5.2.1.
2	6		a. " "
2	7		" "
2	8		" "
2	9		a. Same as 4.15.5.2.2.
2	10		" "
2	11		a. " " and 4.15.5.2.1.
2	12		The document refers only to exposure of Cr-Ni steel to high temperatures for several years. Judge apparently felt that this did not fit the intention of the question.
2	13		a. Same as 4.15.5.2.2.
2	14		" "
2	15		" "
2	16		" "
2	17		" "
2	18		" "
2	19		" "
2	20		" "
2	21		" "

4. 15.5. Failure analysis

Type 1: Known relevant documents not retrieved **Total = 5+28**

Type 2: Non-relevant documents retrieved **Total = 21**

Type	No	Indexing	Reason for Failure
1	1	669.15'24'26-194.56:620.196.2: 620.193.46:543.175-325 Austenitic nickel-chromium alloy steel: intercrystalline corrosion: action of inorganic materials: [nitric acid (see b)]	a. Atmospheric corrosion was not indexed and is not explicitly mentioned in the abstract. An inferred, questionable relevance judgement by one judge. b. Nitric acid is represented by 546.175-325. The number shown does not exist in UDC. A transcription error in the indexing process.
1	2	669.15'26:620.193.54 Chromium alloy steels: effect of an oxidizing atmosphere	a. Error in transcribing the search analyst's prescription. Two terms, 620.193.53 and 620.193.54 were left out.
1	3	669.14.018.293:620.193 Shipbuilding steel: Physical and chemical influences corrosion	a. The document deals with atmospheric corrosion, while the indexing refers to corrosion in general, without regard to environment or agent. Indexing not specific enough.
1	4	669.15'24'26-194.56:620.193.5 Austenitic nickel-chromium alloy steel: effect of hot gases	a. Same as 4.15.5.1.2.
1	5	669.14:621.783.2.012.2: 546.34-38 Steel: Open-fire furnaces! Lithium salts	a. Document deals with protection of steel from oxidation in a furnace. One judge selected this as relevant. The addition is lithium salts, while the search called for chromium, nickel, copper, or phosphorus. The notes are ambiguous as to whether "any material or alloying addition" refers to any one of these four or any additions at all. Also the correlation of atmospheric corrosion and oxidation in a furnace may be somewhat tenuous. Questionable judgement of relevance.
1	6-33	620.193.2... and others	a. Of 71 documents indexed by 620.193.2..., only 43 were retrieved. All of those not retrieved were in a sequence at the beginning of the machine system record for 620.193.2, suggesting a program malfunction.
2	1	620.197.6:620.193.27 Protection of materials by coating: corrosion by sea water	a. Search too loose. No added material is mentioned with respect to steel. However, this applies to some documents chosen as relevant also.
2	2	669.15'24'26-194.56:620.193.27 Austenitic chromium-nickel alloy steel: corrosion by sea water	a. Although corrosion by sea water is specific to atmospheric corrosion in UDC, the judge apparently felt it did not fit the intention of the question. This must be considered to be a questionable judgement, since such inferences about the intention of vague questions (see analyst's notes) cannot be accounted for by the system. It could also be considered to be a search analysis error, as the analyst-judge could have excluded sea water corrosion if he felt it did fit the question.

4.16 Question 16

4.16.1. Question

4.16.1.1. Original Statement Work Hardening of Steels

4.16.1.2. Added Notes None.

4.16.1.3. UDC Analyst's Notes 621.787

4.16.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	621.787	C621787	13

4.16.3. Encoded Logical Statements (condensed form)

(+ = or, * = and, $ = truncation)

1. (A)
2. (A$)

4.16.4. Results and Analysis

4.16.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	0	0	0	0
		E	F	G	H
	Judge 2	0	0	0	0
Total Retrieved by UDC	Judge 1	0	0	0	0
		I	J	K	L
	Judge 2	0	0	0	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	10	9	0	1
		M	N	O	P
	Judge 2	10	3	4	3
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	10	9	0	1
		Q	R	S	T
	Judge 2	10	3	4	3

4.16.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

4. 16.5. Failure analysis

Type 1: Known relevant documents not retrieved Total =9+20

Type 2: Non-relevant documents retrieved Total = 0

Type	No	Indexing	Reason for Failure
1	1	669.141.24-415:539.374:621.983.3 Mild steel - thin plate: plastic deformation: deep drawing	a. Concept "work hardening" not indexed, but mentioned explicitly in the abstract. Indexing failure.
1	2	669.14.018.291.3:620.178.311.81 Concrete-reinforcing steels: effect of notches, surface treatment, and previous treatment of the specimens	a. Concept "work hardening" not indexed and not mentioned explicitly. Questionable judgement by one judge.
1	3	669.14-153+669.15-194.2-153: 539.383:669.2/.8 Annealed steel + annealed low alloy steels: deformation by compression: non-ferrous metals	a. Same as 4.16.5.1.2.
1	4	621.91.014:621.892 Efficiency of cutting or machining: Lubricants	a. Same as 4.16.5.1.1.
1	5	669.14-131.4-157.96:539.42: 539.531 Hot-worked, quenched and tempered steel: Tensile strength: hardness	a. Same as 4.16.5.1.1.
1	6	669.14.24:539.422 Mild steel: fracture	a. Same as 4.16.5.1.1.
1	7	669.15-194:539.389.3:539.374 Alloy steel: Ageing after deformation: Plastic deformation	a. Same as 4.16.5.1.2.
1	8	669.14-177+669.3-177: 620.178.152.32 Work hardened steel and copper: Cone impression process	a. Search analysis error. Analyst did not suggest using -177 auxiliary, which indicates "work-hardened".

4. 16 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total =

Type 2: Non-relevant documents retrieved Total =

Type	No	Indexing	Reason for Failure
1	9	669.14-131.2-157.8:539.56 Cold-worked, age-hardened steel: Brittleness	a. Same as 4.16.5.1.2.
1	10-29	621.787...	Twenty documents indexed by 621.787... were not retrieved by the machine system. No explanation can be offered.

4.17 Question 17

4.17.1. Question

4.17.1.1. Original Statement Ultrasonic Testing of Steel Plates

4.17.1.2. Added Notes Detection of Defects in Steel Plates by ultrasonic techniques.

4.17.1.3. UDC Analyst's Notes

669.14-414: 620.179.16

4.17.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	669.14	C66914	2073
B	-414...	W414$	34
C	620.179.16	C62017916	63

4.17.3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. (A * B * C)
2. (A$ * B * C$)
3. (B * C$)

4.17.4. Results and Analysis

4.17.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	1	1	0	0
		E	F	G	H
	Judge 2	1	1	0	0
Total Retrieved by UDC	Judge 1	1	1	0	0
		I	J	K	L
	Judge 2	1	1	0	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	17	9	4	5
		M	N	O	P
	Judge 2	17	4	8	6
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	17	9	4	5
		Q	R	S	T
	Judge 2	17	4	8	6

4.17.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	$\frac{1}{1}$	$\frac{1}{1}$	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	$\frac{1}{1}$	$\frac{1}{1}$	n.a.	n.a.

4.17 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 8

Type 2: Non-relevant documents retrieved Total = 0

Type	No	Indexing	Reason for Failure
1	1	669.14-413:620.179.16 Steel - thick plate: ultrasonic testing	a. Search analysis error. Analyst specified only -414, medium-thick plate. Question satisfied by reference to any plate, i.e. -412.../-417...
1	2	620.179.16 Ultrasonic testing	a. Document does not mention plates or any other particular shape or form. Judge apparently inferred that any reference to ultrasonic testing is relevant.
1	3	669.14:620.179.161 Steel: ultrasonic testing by transmission	a. Same as 4.17.5.1.2.
1	4	669.14-157.2:620.179.16 Tempered steel: ultrasonic testing	a. Same as 4.17.5.1.2.
1	5	669.13-14+669.14-14:539.4/.5:620.179.16 Cast iron + cast steel: physical properties: ultrasonic testing	a. Same as 4.17.5.1.2.
1	6	621.18:620.179.16 Steam boilers: ultrasonic testing	a. " "
1	7	669.14-418.2:620.179.16 Steel strip: ultrasonic testing	a. Same as 4.17.5.1.2.
1	8	669.14-14:620.179.152 Cast steel: X-ray or gamma-ray testing	a. Same as 4.17.5.1.2. b. Indexing error - document refers to ultrasonic testing, and not to X-ray or gamma-ray testing.

4. 18 Question 18

4.18 .1. Question

4.18 .1.1. Original Statement Effect of Alloying Elements on the properties of low carbon weldable steels.

4.18 .1.2. Added Notes Weldability of carbon steels and effect of alloying elements, C, Mn, Si, Cr, Ni, Mo, Cu, Al, Cb, Zr, Ti, Ta, singly or in combination.

4.18 .1.3. UDC Analyst's Notes

The alloying elements will be found as in previous examples by their simple UDC numbers. Weldability will be found under the precise welding process (621.791...). A search under weldability tests, 620.179.2 may provide some more information.

4.18 .2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	669.15...	C66915$	very many
B	-194...	W194$	958
C	621.791...	C621791$	357
D	620.179.2...	C62017925$	13

4.18 .3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. [A * B * (C + D)]

2. (C + D)

4.18.4. Results and Analysis

4.18.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	1	0	1	0
		A	B	C	D
	Judge 2	1	1	0	0
Retrieved by UDC only	Judge 1	218	16	37	165
		E	F	G	H
	Judge 2	218	18	66	134
Total Retrieved by UDC	Judge 1	219	16	38	165
		I	J	K	L
	Judge 2	219	19	66	134
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	14	4	3	7
		M	N	O	P
	Judge 2	14	0	4	10
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	15	4	4	7
		Q	R	S	T
	Judge 2	15	1	4	10

4.18.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ E}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{0}{4}$	$\frac{1}{8}$	$\frac{16}{0/4}$	$\frac{54}{1/8}$	$\frac{16}{219}$	$\frac{54}{219}$	n.a.	.0472
Judge 2	$\frac{1}{1}$	$\frac{1}{5}$	$\frac{19}{1/1}$	$\frac{85}{1/5}$	$\frac{19}{219}$	$\frac{85}{219}$	.0021	.0464

4.18 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 4

Type 2: Non-relevant documents retrieved Total = 165

Type	No.	Indexing	Reason for Failure
1	1	669.15-194:539.4/.5:669.293 Alloy steel: physical properties: niobium	a. No explicit mention of welding or weldability. Questionable judgement of relevance. The judges seem to differ in their interpretation of the question. One appears to feel that welding or weldability must be specifically mentioned. The other appears to feel that mention of any property of a steel which happens to be weldable is sufficient. b. The concept "weldability" is expressed by 539.512, which the search analyst did not suggest. However, the indexing did not bring out this property specifically.
1	2	669.14.241.4:539.4/.5:669.292 Unkilled steel: physical properties : vanadium	a. Same as 4.18.5.1.1a, b.
1	3	669.14-155.3:669.781 Case-carburized steel: boron	a. Same as 4.18.5.1.1a, b.
1	4	669.141.241.4:669.71 Unkilled steel: aluminum	a. Same as 4.18.5.1.1a,b.
2	1-165		Some reasons which may account for the high percentage of rejection: a. Joining or welding of a carbon steel containing alloying elements is reported without mention of the effect on properties; b. The steel is not a carbon steel; or welding of iron is the subject. Although the numbers of documents chosen as relevant by the judges were 16 and 18 respectively, there were only 6 on which both judges agreed. The first search formulation (4.18.3.1.) caused retrieval of 55 abstracts. Of the 6 chosen as relevant by both judges, 4 were retrieved by this search formulation.

(continued on next page)

4.18 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = |

Type 2: Non-relevant documents retrieved | Total = |

<table>
<tr><th>Type</th><th>No</th><th>Indexing</th><th>Reason for Failure</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><th>Group</th><th>No. Chosen Relevant</th></tr>
<tr><td>1</td><td>8</td></tr>
<tr><td>2</td><td>6</td></tr>
<tr><td>3</td><td>1</td></tr>
<tr><td>4</td><td>2</td></tr>
<tr><td>5</td><td>0</td></tr>
<tr><td>6</td><td>2</td></tr>
<tr><td>7</td><td>0</td></tr>
<tr><td>8</td><td>4</td></tr>
<tr><td>9</td><td>1</td></tr>
<tr><td>10</td><td>3</td></tr>
<tr><td>11</td><td>3</td></tr>
<tr><td>TOTAL</td><td>30</td></tr>
</table>
</td><td>
<p>There was some suggestion of influence of the order in which the abstracts were presented to the judges. If the 219 abstracts retrieved are grouped by 20's, the following number of documents were chosen as relevant by at least one judge. Nearly half of all those chosen were from the first 40 viewed.</p>
<p>A tighter search formulation was apparently warranted. That represented by 4.18.3.1 would have narrowed the number retrieved considerably. An examination of the six chosen by both judges and the one document retrieved by both systems and judged relevant by one judge shows that all seven were indexed by 621.791.75..., arc welding, although this degree of specificity was not suggested explicitly by the question.</p>
<p>The alert reader will also have sensed another unexplained machine search failure. Search formulation 4.18.3.2 should have caused 370 documents to be retrieved, while only 219 were retrieved.</p>
</td></tr>
</table>

4.19 Question 19

4.19.1. Question

4.19.1.1. Original Statement Mercury Corrosion of Stainless Steel

4.19.1.2. Added Notes Any effect of mercury at ambient temperatures on corrosion, cracking, embrittlement or any other mechanical properties or stainless steels.

4.19.1.3. UDC Analyst's Notes

See earlier replies for stainless steel. Embrittlement will be denoted by :539.56, Hg is 669.791. For corrosion 620.193.93 (Actually, the effects of scorification and slagging and thus the only suitable place for molten metals) should be searched.

4.19.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	539.56...	C53956$	215
B	669.14...	C66914$	very many
C	.018.8...	X188$	406
D	669.791...	C669791$	2
E	620.193.93...	C62019393$	7
F	620.193...	C620193$	355

4.19.3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. [(A + E) * B * C * D]

2. {[B * C * (A + D + E)] + [D * (A + E)]}

3. {[B * C * (A + D + F)] + [D * (A + F)]}

4.19.4. Results and Analysis

4.19.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	39	0	1	38
		E	F	G	H
	Judge 2	39	0	3	36
Total Retrieved by UDC	Judge 1	39	0	1	38
		I	J	K	L
	Judge 2	39	0	3	36
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	0	0	0	0
		M	N	O	P
	Judge 2	0	0	0	0
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	0	0	0	0
		Q	R	S	T
	Judge 2	0	0	0	0

4.19.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	$\frac{0}{39}$	$\frac{1}{39}$	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	$\frac{0}{39}$	$\frac{3}{39}$	n.a.	n.a.

4. 19.5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 0

Type 2: Non-relevant documents retrieved Total = 37

Type	No	Indexing	Reason for Failure
2	1-37		Faulty translation of the search analyst's formulation into a logical statement for the machine system. No form of the question should have permitted retrieval without 669.791, mercury, as a part of the indexing record.

4.20 Question 20

4.20.1. Question

4.20.1.1. Original Statement Improvement of Mechanical Properties of Steel by Combined Deformation and heat treatment

4.20.1.2. Added Notes Mechanical Properties of Steels as influenced by Ausforming, Ausworking, Ausrolling or by Ausforging.

4.20.1.3. UDC Analyst's Notes

Not an easy one. 621.785+621.787 (Equals heat treatment plus work hardening)

4.20.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	621.785	C621785	129
B	621.787	C621787	13

4.20.3. Encoded Logical Statements (condensed form)

(+ = or, * = and, $ = truncation)

1. (A * B)

2. (A$ * B$)

4.20.4. Results and Analysis

4.20.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	2	2	0	0
		E	F	G	H
	Judge 2	2	2	0	0
Total Retrieved by UDC	Judge 1	2	2	0	0
		I	J	K	L
	Judge 2	2	2	0	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	9	8	1	0
		M	N	O	P
	Judge 2	9	8	1	0
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	9	8	1	0
		Q	R	S	T
	Judge 2	9	8	1	0

4.20.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	$\frac{2}{2}$	$\frac{2}{2}$	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	$\frac{2}{2}$	$\frac{2}{2}$	n.a.	n.a.

4.20 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 8 |

Type 2: Non-relevant documents retrieved | Total = 0 |

Type	No	Indexing	Reason for Failure
1	1	669.14-426:621.785.79 Steel wire: complex or combined tempering, quenching, ageing, or temper-hardening combined with work hardening	a. Search analysis failure. Analyst did not specify 621.785.79 as a possible alternative to 621.785 * 621.787. b. This case might be viewed as an unnecessary complication in the UDC. It is questionable whether 621.785.79 is needed as a class when the concept could be represented by synthesis, e.g. 621.785'787.
1	2	621.785.79 and others	a. Same as 4.20.5.1.1.
1	3	669.14.018.29-157.9:539.537 Structural steels - treated by combined processes: resistance to impact	a. Another case similar to 4.20.5.1.1a,b. The auxiliary form -157.9 appears to be a third way of expressing the same synthesis of processes.
1	4	669.14.018.29:621.785.79	a. Same as 4.20.5.1.1.
1	5	669.14.018.29:669.112.227.1:539.374 Structural steels: austenite: Plastic deformation	a. Search analysis failure. Analyst did not specify use of 539.374, plastic deformation. b. Indexing failure. Heat treatment not indexed.
1	6	621.785.79 and others	a. Same as 4.20.5.1.1.
1	7	621.785.79 " "	a. Same as "
1	8	621.785.79 " "	a. Same as "

4. 21 Question 21

4. 21.1. Question

4. 21.1.1. Original Statement Internal Friction of Fe Alloys and Co and Ni Superalloys

4. 21.1.2. Added Notes Programmed for internal friction in iron-base alloys including steels only. Includes Co-base and Ni-base Superalloys only when have Fe as a major component.

4. 21.1.3. UDC Analyst's Notes

1) 669.15: Iron Alloys
   539.67: Internal Friction
2) 669.15'24: Iron-Nickel Alloys
   539.67
3) 669.15'25: Iron-Cobalt Alloys
   539.67
4) 669.15'24'25: Iron-Nickel Cobalt...
   539.67

4. 21.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	669.15	C66915	411
B	539.67...	C53967$	27
C	669.15'24	C66915Y24	139
D	669.15'25	C66915Y25	11
E	669.15'24'25	C66915Y24Y25	0

4. 21.3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. [B * (A + C + D + E)]

2. (A$ * B)

3. (B)

4.21.4. Results and Analysis

4.21.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	5	2	3	0
		A	B	C	D
	Judge 2	5	5	0	0
Retrieved by UDC only	Judge 1	11	3	5	3
		E	F	G	H
	Judge 2	11	11	0	0
Total Retrieved by UDC	Judge 1	16	5	8	3
		I	J	K	L
	Judge 2	16	16	0	0
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	5	1	1	3
		M	N	O	P
	Judge 2	5	2	1	2
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	10	3	4	3
		Q	R	S	T
	Judge 2	10	7	1	2

4.214.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{2}{3}$	$\frac{5}{7}$	$\frac{5}{2/3}$	$\frac{13}{5/7}$	$\frac{5}{16}$	$\frac{13}{16}$	.0008	.0020
Judge 2	$\frac{5}{7}$	$\frac{5}{8}$	$\frac{16}{5/7}$	$\frac{16}{5/8}$	$\frac{16}{16}$	$\frac{16}{16}$	.0024	.0028

4.21 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 2

Type 2: Non-relevant documents retrieved Total = 3

Type	No	Indexing	Reason for Failure
1	1	669.15-194.55/.56: 669.14.018.8-15:539.4/.5 Martensitic-austenitic alloy steels: heat treated stainless steels: physical properties	a. "Internal friction" (539.67) not indexed, but mentioned specifically in the abstract. 539.4/.5 seems to have been used as a catch-all term for properties, several of which were discussed.
1	2	669.12:539.412.011.23:669.788 Pure iron: Resistance to tension - lower yield point: hydrogen	a. Same as 4.21.5.1.1. Judged relevant by one judge even though pure iron, not alloys, was the subject.
2	1	669.112.228:539.67:669.786: 621.785.78 Alpha-iron: internal friction: nitrogen: ageing	a. (refer to 4.21.5.1.2 - this was judged irrelevant by the other judge). Search formulation 4.21.3.3 was too loose - it did not require alloys to be a subject.
2	2	669.12:539.125.5.043:539.67 Pure iron: physical effect of neutrons: internal friction	a. Same as 4.21.5.2.1.
2	3	669.12-172:548.4:539.67 Pure iron - single crystals: dislocations: internal friction	a. Same as 4.21.5.2.1.

4.22 Question 22

4.22.1. Question

4.22.1.1. Original Statement Continuous Casting of Stainless and Alloy Steels

4.22.1.2. Added Notes

None.

4.22.1.3. UDC Analyst's Notes

1) 669.14.018.8: Stainless Steels
621.74.047 Continuous Casting

2) Iron, Fe-Ni, Fe-Co , Fe-Ni-Co alloys as above.

4.22.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	621.74	C62174	133
B	.047...	X47$	125
C	669.14	C66914	2073
D	.018.8...	X188$	406
E	669.15	C66915	411

4.22.3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. [A * B * D * (C + E)]

2. [A$ * B * D * (C$ + E$)]

3. (A$ * B)

4. 224. Results and Analysis

4. 224.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	9	4	2	3
		A	B	C	D
	Judge 2	9	3	6	0
Retrieved by UDC only	Judge 1	53	12	13	28
		E	F	G	H
	Judge 2	53	6	45	2
Total Retrieved by UDC	Judge 1	62	16	15	31
		I	J	K	L
	Judge 2	62	9	51	2
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	8	5	1	2
		M	N	O	P
	Judge 2	8	0	6	2
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	17	9	3	5
		Q	R	S	T
	Judge 2	17	3	12	2

4.22.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{4}{9}$	$\frac{6}{12}$	$\frac{16}{4/9}$	$\frac{31}{6/12}$	$\frac{16}{62}$	$\frac{31}{62}$	.0039	.0068
Judge 2	$\frac{3}{3}$	$\frac{9}{15}$	$\frac{9}{3/3}$	$\frac{60}{9/15}$	$\frac{9}{62}$	$\frac{60}{62}$	.0010	.0109

4. 22.5. Failure analysis

Type 1: Known relevant documents not retrieved Total = 5

Type 2: Non-relevant documents retrieved Total = 32

Type	No	Indexing	Reason for Failure
1	1	621.746.5:669-987 Pouring: High pressure process	a. The "continuous" aspect was not indexed, although mentioned in the abstract.
1	2	669.14.018:621.746+669.183/.187 Steels by property: casting: open-hearth, converter, and crucible steel processes	a. Same as 4.22.5.1.1.
1	3	621.74.047 Continuous casting	a. Unexplained search failure. Should have been retrieved.
1	4	669.14-147:620.192.46 Continuously-cast steel: internal tears	a. Search analyst did not suggest use of -147, "continuously cast". b. Provision of a class for a process and another for metal produced by the process may be viewed as questionable in the UDC.
1	5	621.74.047-111.3 Inclined or skewed machines for continuous casting	a. Same as 4.22.5.1.3.
2	1-32		a. Search formulation 4.22.3.3 was too loose. These non-relevant documents refer to continuous casting, but not to stainless or alloy steels.

4.23 Question 23

4.23.1. Question

4.23.1.1. Original Statement High Temperature Extrusion of Steels and Apparatus Therefor

4.23.1.2. Added Notes

None.

4.23.1.3. UDC Analyst's Notes

621.777.2.016.2 covers both aspects of the definition.

4.23.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	621.777.2	C6217772	16
B	.016.2...	X162$	87
C	621.774.38...	C62177438$	6

4.23.3. Encoded Logical Statements (condensed form)

(+ = or, * = and, $ = truncation)

1. (A * B)
2. (A$ * B)
3. [(A$ + C) * B]
4. (A$ + C)

4.23.4. Results and Analysis

4.23.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	3	1	0	2
		A	B	C	D
	Judge 2	3	1	0	2
Retrieved by UDC only	Judge 1	22	18	0	4
		E	F	G	H
	Judge 2	22	7	11	4
Total Retrieved by UDC	Judge 1	25	19	0	6
		I	J	K	L
	Judge 2	25	8	11	6
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	15	7	5	3
		M	N	O	P
	Judge 2	15	3	3	9
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	18	8	5	5
		Q	R	S	T
	Judge 2	18	4	3	11

4.23.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{1}{8}$	$\frac{1}{13}$	$\frac{19}{1/8}$	$\frac{19}{1/13}$	$\frac{19}{25}$	$\frac{19}{25}$	.0166	.0270
Judge 2	$\frac{1}{4}$	$\frac{1}{7}$	$\frac{8}{1/4}$	$\frac{19}{1/7}$	$\frac{8}{25}$	$\frac{19}{25}$	.0035	.0145

4.23 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 7 |

Type 2: Non-relevant documents retrieved | Total = 6 |

Type	No	Indexing	Reason for Failure
1	1	669.15-194:621.7.016.2 Alloy steels: High temperature plastic working, forming, and treatment of materials	a. Concept "extrusion" (621.777.016.2) present in abstract but indexed only to the extent implied by the descriptor 621.7.016.2, two hierarchical levels broader than specified. Indexing failure.
1	2	621.7.016.2/.3 and others	a. Same as 4.23.5.1.1.
1	3	621.774.38.073	a. Unexplained machine search error. Should have been retrieved by 4.23.3.3.4.
1	4	621.774 Tube and pipe manufacture	a. A general review paper. Questionable, inferential judgement.
1	5	669.15-194:534.4/.5:621.785.79 Alloy steels: [physical properties (see b.)]: combined or complex heat treatment	a. Concept "extrusion" not indexed, but explicit in title. Indexing failure. b. Transcription error in the indexing process. 534.4/.5 does not exist in the metallurgy edition of UDC - 539.4/.5 is intended.
2	1-6		a. Search formulation 4.23.3.4 was too loose. All of these documents referred to cold working conditions. The auxiliary .016.2 should not have been dropped from the search.

4.24 Question 24

4.24.1. Question

4.24.1.1. Original Statement Vacuum Metallurgy of Steels

4.24.1.2. Added Notes None.

4.24.1.3. UDC Analyst's Notes

In general 669-982 will recover all on degassing or any other operation on Liquid steel. Vacuum Heat treatment requires the addition of .061 to the number for the process.

4.24.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A.	669...	C669$	very many
B	-982...	W982$	184
C	62...	C62$	very many
D	.061...	X61$	11

4.24.3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. {[(A + C) * B] + (A * D)}
2. [B + (A * D)]

4.24.4. Results and Analysis

4.24.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	1	1	0	0
		A	B	C	D
	Judge 2	1	1	0	0
Retrieved by UDC only	Judge 1	182	140	36	6
		E	F	G	H
	Judge 2	182	157	22	3
Total Retrieved by UDC	Judge 1	183	141	36	6
		I	J	K	L
	Judge 2	183	158	22	3
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	4	2	0	2
		M	N	O	P
	Judge 2	4	0	2	2
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	5	3	0	2
		Q	R	S	T
	Judge 2	5-	1	2	2

4.24.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{141}{1/3}$	$\frac{177}{1/3}$	$\frac{141}{183}$	$\frac{177}{183}$	.0461	.0580
Judge 2	$\frac{1}{1}$	$\frac{1}{3}$	$\frac{158}{1/1}$	$\frac{180}{1/3}$	$\frac{158}{183}$	$\frac{180}{183}$	.0172	.0590

4.24 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 2 |

Type 2: Non-relevant documents retrieved | Total = 7 |

Type	No	Indexing	Reason for Failure
1	1	669.15'26'74-194+669.15'74-194: 539.319:621.785.796 Chromium-manganese and manganese alloy steels: internal stress due to technical operations: quenching and tempering	a. Concept "vacuum arc remelting" is present in the abstract, but not indexed.
1	2	620.192.45:539.431 Inclusions: fatigue, creep	a. "Vacuum remelted steel" referred to in title, but not indexed.
2	1	669-982:620.172.251.2 Vacuum: creep tests for metals at high temperatures	a. Describes apparatus for tensile testing under vacuum. Apparently judge felt that this was not what was meant by vacuum metallurgy. (see 4.24.5.2.4, below)
2	2	669.15'71+669.15'782:539.67+ 620.172.225:669-982 Aluminum and silicon alloy steels: internal friction: measurement of modulus of elasticity: vacuum	a. Same as 4.24.5.2.1.
2	3	536.423:543.42:669-982 Vapor pressure: spectrum and fluorescence analysis: vacuum	a. Deals with evaporation of a metal from cylindrical vessels in vacuo. No obvious reason for judgement of non-relevance by one judge.
2	4	66.023-982:669.14.018.6:539.56 Vacuum reaction vessels: alloys with special physical properties: Brittleness	a. Auxiliary -982 used here to signify reactor apparatus which may be used under vacuum conditions. The question refers to metallurgical processes under vacuum. This may be considered to be (1) an indexing error (2) a deficiency in UDC - ambiguous use of -982 owing to lack of more appropriate descriptors.
2	5	669.15'26'28-194+ 669.15'26'74-194:621.979.25.061 Chromium-molybdenum + chromium-manganese alloy steels: extruding presses - presser plates	a. False coordination. (669... * .061...) was the intended strategy.

4.24 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total =

Type 2: Non-relevant documents retrieved Total =

Type	No	Indexing	Reason for Failure
2	6	669.13-154:669.046.517-982: 539.4/.5 Molten cast iron: degassing the melt under vacuum: physical properties	a. No apparent reason for judgement of non-relevant by one judge.
2	7	621.794.48:548.53:669-982 Reclaiming and reutilization of pickling residues: recrystallization: vacuum	a. Apparently a chemical process peripheral to metallurgy.

4.25 Question 25

4.25.1. Question

4.25.1.1. Original Statement Vanadium in Steels

4.25.1.2. Added Notes Influence of Vanadium additions to steels on quenching, tempering, hardening, phase composition, carbide structures and mechanical properties.

4.25.1.3. UDC Analyst's Notes

In general, 669.292 will recover all on the effects of Vanadium in steels. It will also recover material in determination of vanadium and the very little on vanadium itself.

4.25.2. UDC Descriptors Chosen

Line	Descriptor	Encoded Descriptor	Frequency of Posting
A	669.292	C669292	18

4.25.3. Encoded Logical Statements (condensed form)
(+ = or, * = and, $ = truncation)

1. (A)
2. (A$)

4.25.4. Results and Analysis

4.25.4.1. Relevance Judgements

Characteristic	Judges	Total	Relevant	Marginally Relevant	Non-Relevant
Retrieved by Both Systems	Judge 1	0	0	0	0
		A	B	C	D
	Judge 2	0	0	0	0
Retrieved by UDC only	Judge 1	18	10	0	8
		E	F	G	H
	Judge 2	18	17	0	1
Total Retrieved by UDC	Judge 1	18	10	0	8
		I	J	K	L
	Judge 2	18	17	0	1
Retrieved by ASM only, but covered by ISI ABTICS	Judge 1	4	1	0	3
		M	N	O	P
	Judge 2	4	2	0	2
Total Retrieved by both systems (Line 1) and by ASM only	Judge 1	4	1	0	3
		Q	R	S	T
	Judge 2	4	2	0	2

4.25.4.2. Derived Performance Characteristics

Characteristic	Estimated Recall		Estimated No. of Relevant Documents in ISI ABTICS		Precision		Estimated Specificity	
Base	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal	Relevant only	Relevant + Marginal
Formula	$\frac{B}{R}$	$\frac{B+C}{R+S}$	$\frac{J}{B/R}$	$\frac{J+K}{(B+C)/(R+S)}$	$\frac{J}{I}$	$\frac{J+K}{I}$	$\frac{JR}{9159\ B}$	$\frac{(J+K)(R+S)}{9159(B+C)}$
Judge 1	n.a.	n.a.	n.a.	n.a.	$\frac{10}{18}$	$\frac{10}{18}$	n.a.	n.a.
Judge 2	n.a.	n.a.	n.a.	n.a.	$\frac{17}{18}$	$\frac{17}{18}$	n.a.	n.a.

4.25 .5. Failure analysis

Type 1: Known relevant documents not retrieved | Total = 2 |

Type 2: Non-relevant documents retrieved | Total = 8 |

Type	No	Indexing	Reason for Failure
1	1	669.15'24'26'28'292-194: 621.791.011:539.42 Nickel-chromium-molybdenum-vanadium alloy steels: weldability : tensile strength	a. The present version of the retrieval system does not process the UDC synthetic concept notation to full advantage. The request for 669.292 could not retrieve this document, indexed by 669.[...]'292.
1	2	669.15'292-194:669.112.227.34 Vanadium alloy steels: martensite formation	a. Same as 4.25.5.1.1.
2	1	669.15'27'28-194: 669.14.018.252.3:539.4/.5: 669.292 Tungsten-molybdenum alloy steels: high speed steels: physical properties: vanadium	a. The document deals with effect of additions of Al, Ti, B, and Nb/Ta on W-Mo steel which is high in vanadium content. This failure may be considered to be the result of ambiguity in the indexing. The UDC does not provide an unambiguous method for distinguishing between descriptive characteristics (W-Mo steel, high in V) and constituents actively involved in a cause-effect relationship (Al, Ti, B, Nb/Ta) b. Although the result of this search was not influenced by it, there was a failure to index the causative agents, namely Al, Ti, B, and Nb/Ta.
2	2	669.26+669.292+669.74:543.257.5 Chromium + vanadium + manganese: amperometric analysis	a. The UDC does not permit differentiation of determination of V from V as an influence on properties of a steel, as pointed out by the search analyst's notes. The document might have been excluded by a request for [669.292 and not 543...], but at the risk of excluding documents which deal with both determination and influence of vanadium.
2	3	669.15'26'28'292-194:669.292: 539.434 Chromium-molybdenum-vanadium alloy steels: vanadium: creep strength	a. Probable indexing error. The document deals with effect of molybdenum on Cr-Mo-V steel.
2	4	669.112.228+669.292:541.124: 669.784+669.786 Alpha range of the iron-carbon system + vanadium: chemical dynamics: carbon + nitrogen	a. Document deals with vanadium alone, not in reference to steel. It is included in a collection on ferrous metallurgy because it deals also with iron.

4.25 .5. Failure analysis

Type 1: Known relevant documents not retrieved Total =

Type 2: Non-relevant documents retrieved Total =

Type	No	Indexing	Reason for Failure
2	5	669.14:669.292:543.432 Steel: vanadium: colorimetric analysis	a. Same as 4.25.5.2.2.
2	6	669.12-154:531.75+532.61:669.292 Molten pure iron: measurement of mass and density + surface tension: vanadium	a. Document deals with an iron-vanadium system, not with steel. Search formulation was too loose. It should have been [669.292 * (669.14... + 669.15...)].
2	7	669.15'784:669.292:531.75+532.612.4 Carbon-steel alloys: vanadium: measurement of mass and density + surface tension of liquids	a. Same as 4.25.5.2.4.